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Pamphlets on Forestry in Vermont

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FORESTRY PAMPHLETS

Vermont

Vol. III

A Marketing Study of Woodlots to be made by the Vermont Forestry Department. Vermont Forestry Publication No. 21. By A. F. Hawes, State Forester.

First Annual Report, Vermont Timberland Owners Association, 1915.

1917 Annual Report, Vermont Timberland Owners' Association.

Studies in Tolerance of New England Forest Trees. Bulletin No. 178, Vermont Agricultural Experiment Station.

Studies in Tolerance of New England Forest Trees. III. Discontinuous Light in Forests. By G. P. Burns. Bulletin 193, Vermont Agri. Experiment Station.

The Red Rot of Conifers. By F. H. Abbott. Bulletin 191, Vermont Agri. Exp. Sta.

Forest Nursery Stock for Distribution in the Spring of 1911. Circular No. 6. Vermont Agricultural Experiment Sta.

The Gypsy and Brown Tail Moths. By Wm. Stuart. Cir. No. 2, Vt. Agri. Exp. Sta

The Forest Caterpillar. Bulletin No. 76, Vermont Agri. Experiment Station.

State Nursery for Forest Tree Seedlings. Bulletin No. 127, Vt. Agri. Exp. Sta.

Forest Planting in Vermont. Bulletin No. 132. Vermont Agri. Experiment Station.

Abstract Twentieth Report, 1906-07, Vermont Agri. Experiment Station (Crops, Forestry, Stock Feeding, Dairy Husbandr

Preliminary Statement regarding the Forestr Problems of Vermont. Bulletin No. 139, Vermont Agricultural Experiment Station

Forestry. Summary Bulletin 139. By A. F. Hawes, State Forester.

The Damping Off of Coniferous Seedlings. Bulletin No. 157. Vermont Agricultural Experiment Station.

Hemlock in Vermont. Comparative Study of Log Rules. Bul. 161. Vt. Agricultural

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Vermont Vol. III (Cont'd)

Forest Planting in Vermont as an Investment
   Bulletin No. 188, Vermont Agricultural
   Experiment Station.
A Forestry Arithmetic for Vermont Schools.
   Vermont Forestry Publication No. 14.
   By A. F. Hawes.
The Trees of Vermont. By G. P. Burns and
   C. H. Otis. Vermont Agricultural Experiment Station Bulletin 194.
Extract from Report of the Director, July,
   1916, Bulletin 199.
Sixth Annual Report of the State Forester,
   1914. Progress of Forestry in Vermont.
Seventh Annual Report of the State Forester
   1915. Forestry in Vermont.
Eighth Annual Report of the State Forester,
   1916. Forestry in Vermont.

Agric. Forestry. Main Library

First Annual Report

Bloomfield, Vermont, 1915

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Officers.

H. G. **Philbrook**, President,
Connecticut Valley Lumber Co.

E. E. **Amey**, Vice-President,
International Paper Co.

G. R. **Monell**, Sec.-Treas., Forester,
Bloomfield, Vermont.

Directors.

H. G. **Philbrook**, Connecticut Valley Lumber Co.

E. E. **Amey**, International Paper Co.

C. C. **Wilson**, Odell Manufacturing Co.

W. R. **Brown**, Berlin Mills Co.

A. N. **Blandin**, Deerfield Lumber Corporation.

Forester's Report.

Since its organization on April 2, 1915, with four members, the Vermont Timberland Owners' Association has increased its membership to fourteen, representing a total area of 275,128 acres.

In several instances, the State has cooperated with the Association, thereby giving the Association territory closer supervision and protection than would otherwise have been possible. Because of the late date of the organization of the Association, no Federal cooperation was obtainable during the past season. However, another year a large part of the Federal funds received by the State will be expended in Association territory.

This year, the Association erected a mountain look-out station (cabin and tower) on West Pond Mountain in the town of Ferdinand, and another look-out station on Sable Mountain in the town of Averill was turned over to the Association, at the end of the season, by the Connecticut Valley Lumber Co., who has also given the Association four camps in different towns in Essex County, to be used as headquarters for patrolmen.

The Association has been fortunate in the amount of supervision it has been able to maintain over its patrolmen and watchmen. All of its cabins but two are reached by telephone and all the patrolmen and watchmen, except those in the cabins without telephones, reported by telephone at least once, and many of them twice a day, either to the Association's Forester, or to some member of the Association or their employee. The other two patrolmen made weekly reports.

Twenty-six miles of telephone line, which connects all the patrolmen's cabins in Essex County with the headquarters of the Association, together with six complete telephone sets were given to the Association by the Connecticut Valley

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Lumber Co. The only new line that had to be erected this year, therefore, was one of four miles, connecting the West Pond Mountain Station with the main line.

The Association was fortunate also in obtaining free exchange service from the Coos Telephone Co., and their generous support and co-operation is hereby acknowledged.

The fire season started earlier the past year than usual, due to the small fall of snow during the winter of 1914-1915 and an early spring drought. May and June were the dryest months, and the only serious fires occurred during this period.

1915 Forest Fires in Association Territory.

No. of towns Affected.	No. of Fires.	Total Area Burned.	Average Area Burns.
8	18	2,301 ac.	128 ac.

Of the 18 fires, only 5 burned over more than one acre. The other 13 fires were discovered soon after their starting and quickly put out, many of them by Association patrolmen.

Association Patrol.

The Association had 10 men on patrol work during the past fire season, most of whom were permanently employed. Of this number the State helped to pay one and the Grand Trunk Railway and the State cooperated in paying one other.

These patrolmen not only warned every person they met in the woods about the danger of forest fires, but also took the names and addresses of several hundred; each one of these will receive a Vermont forest fire law book this year. It has been of considerable aid to the patrolmen in this work to wear the Association fire warden badges made up for them.

Following is a list showing the routes of the patrolmen employed during the past season.

ROUTE.	TOWNS.
1. Grand Trunk Railway, from Summit to Lake.	Morgan, Warren Gore, Norton.

2.	East and Black branches of the Nulhegan river.	Bloomfield, Averill, Lewis.
3.	Fitch and Guay Brooks and Granby branch of Paul Stream.	Granby, East Haven, Ferdinand.
4.	Sterling Mt. District.	Cambridge, Johnson.
5.	Moose River Valley.	Victory, Granby, East Haven.
6.	Tributaries of Winooski River.	Duxbury, Fayston.
7.	White River Valley.	Rochester, Pittsfield, Hancock.
8.	Bourn Brook Valley.	Manchester, Sunderland.
9.	Deerfield River Valley.	Somerset, Stratton, Searsbury.
10.	La Moille River Tributaries.	Cambridge, Johnson.

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Secretary-Treasurer's Report.

April 2, 1915 to December 31, 1915.

Receipts.

Assessments at 1 cent per acre	$ 2,751 31

Expenditures.

Patrol	$ 1,516 98
Building fire station	78 96
Telephone account (new line)	89 81
Advertising and badges	39 40
Taxes (inc. incorporation)	37 58
Office expenses	71 38
Travelling expenses	93 98
	$ 1,928 09
Cash on deposit	$ 651 87
Unpaid assessments	171 35
Total carried over	$ 823 22

NOTE: No charges were made for the services of the Sec.-Treas. and Forester nor for office rental.

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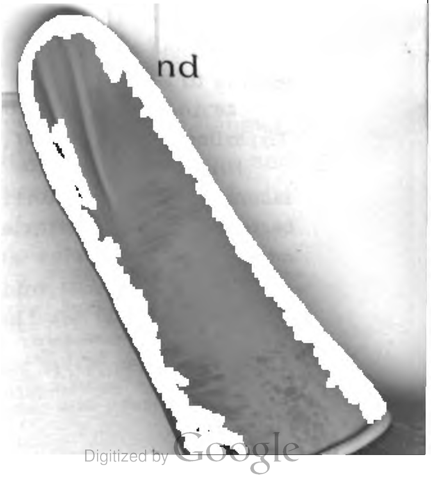

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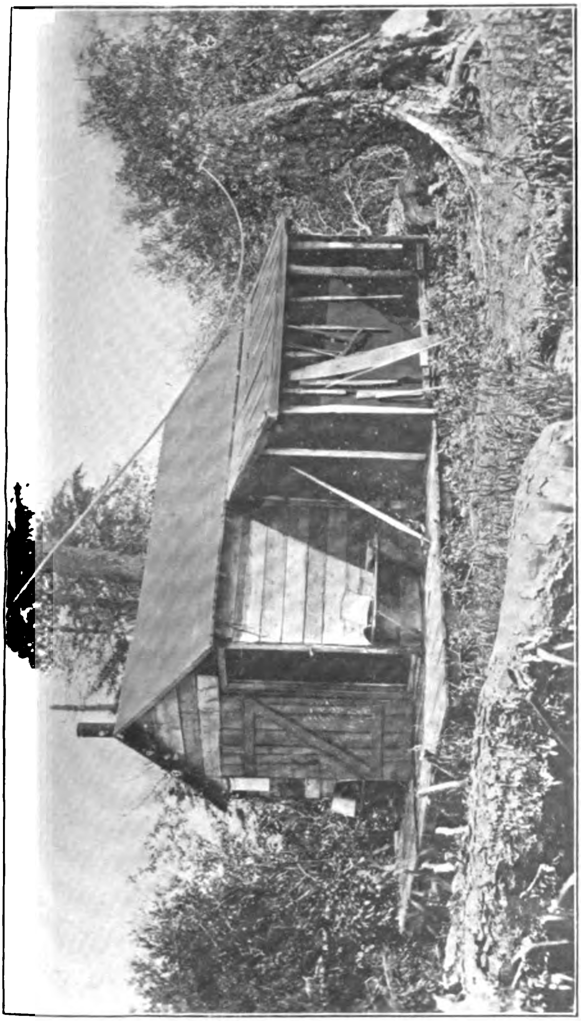
Although the weather conditions were favorable the past season, yet it was thought advisable to collect the full assessment of one cent per acre, so that the Association would have some money ahead as a working basis for the beginning of the 1916 fire season. Besides this $651.87 on deposit the Association owns five patrolmen's camps fully equipped, twenty-six miles of telephone lines, six telephone sets, three pairs of field glasses, ten patrolmen's badges and a number of small tools.

In the way of advertising the Association has sent out more than 100 personal letters to the timberland owners of Vermont, describing the purposes and plans of the Association and urging the cooperation of each owner. This subject has also been brought before the fire wardens of the State at their meetings. It is planned to expend more money on advertising this year, and it is hoped that every member will do their part in extending a knowledge of the purposes and aims of this Association.

HELP PREVENT
FOREST FIRES



Vermont Timberland Owners Association Watchman's Cabin on West Pond Mountain

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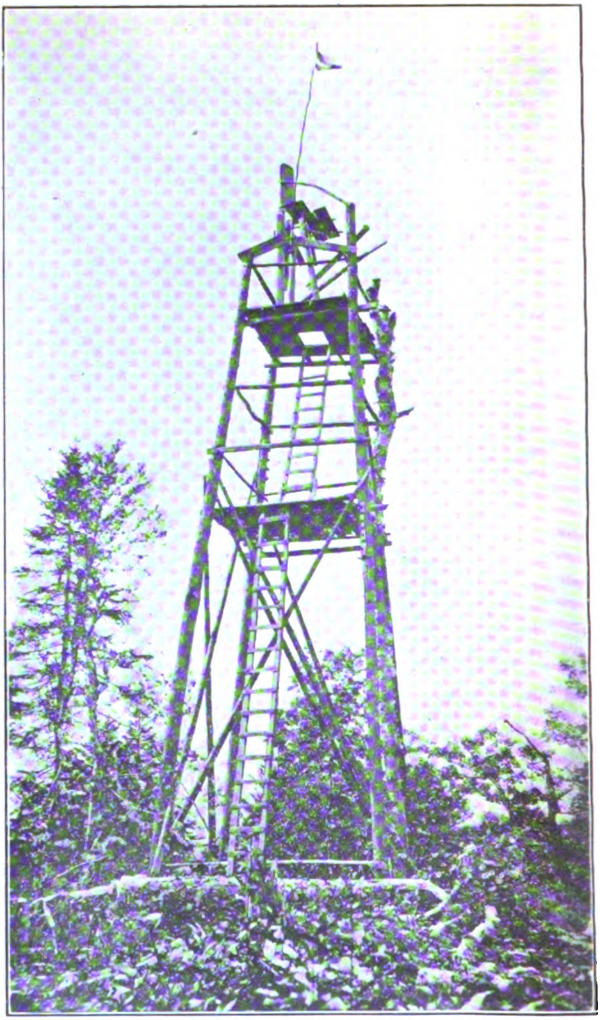

Vermont Timberland Owners Association Fire Look-out Station on West Pond Mountain, Ferdinand, Vermont.

A MARKETING STUDY OF WOODLOTS
TO BE MADE BY
THE VERMONT FORESTRY DEPARTMENT

[illegible]

[illegible]

BY

A. F. HAWES, State Forester

[illegible]

Vermont Forestry Publication

No. 21

ST. ALBANS MESSENGER CO., PRINT
1916

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Vermont Timberland Owners Association Fire Look-o
Station on West Pond Mountain, Ferdinand, Vermont

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INTRODUCTION

In various annual reports, the State for- ster has published the offer of assistance hich he has made to Woodland owners. his assistance has been chiefly along silvi- ultural lines, that is, it has had as its aim the roduction of more lumber and of better rades. As published in the report, this offer as follows:

(1) The Forestry Department will send ne or more men to inspect any land in the tate, and advise on its management. The nly cost will be that of traveling expenses o and from Burlington, and board while doing he work.

(2) The Department will supervise the arking of trees, which should be cut. On racts of less than ten acres the owner will be xpected to furnish one man; on larger tracts wo men.

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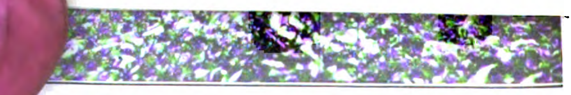
3. Working plans for private forest tract will be made under special agreements, th expense being divided and the party givin satisfactory guarantee that the plan will b executed. A report on the work, done unde the recommendations of the previous in spection, will be required before anothe inspection will be made. The Department reserves the right to publish the reports o such inspections, and the results of work done under such recommendations.

Many land-owners have taken advantage o the foregoing offer. In the town of Barnet there are several good pine lots which have been thinned as marked by the Department. In Windham, Windsor and Orange counties in co-operation with the County agents, the Department has inspected numerous woodlots and given personal advice to the owners. In the town of Middlesex a large lumber operation, which has already extended over several years, has been made with strict adherence to the marking of a forester. In the same way extensive operations are now



ermont Timberland Owners Association Fire Look-o
Station on West Pond Mountain, Ferdinand, Vermont

being conducted in Duxbury, and in other places. It is safe to estimate that at least 10,000 acres of private land, aside from plantations, are being managed under the foregoing offer, and that over one million board feet a year is being so cut.

These figures are undoubtedly small when compared to the total wooded area and total cut of the state, but they indicate a favorable tendency.

Assistance in Marketing.

It is now proposed to go farther and give the woodlot owners assistance in the marketing of their products. The chief difficulty, which the farmer has today in selling his wood and logs is due to the limited amount which he has of any one kind. Except for his own use it is hardly worth while to have his logs custom-sawed, because he cannot ship his lumber in car load lots. The mill man buying from several land owners is in a position to do this. Woodlot owners, how-

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ever, often suffer either because of their distance from a mill, or because of the utter lack of competition between buyers.

The value of logs delivered at the mill and the grade of log that can be sold at a profit depends on the character of the mill and the form in which the lumber is sold. The small mill which can manufacture only rough lumber, and this in such small quantities that it must be sold without grading, can afford to handle only high grade logs, and pay only minimum prices. On the other hand the mill which is equipped for manufacturing a large variety of products, and has worked up a trade so that it can ship graded and partially manufactured lumber in car load lots, can not only use a much lower grade of log profitably but can pay more for any given grade of log.

One of the chief factors in successful lumber business today is the proper grading of lumber. The larger saw mills employ men who are experts in grading lumber under the rules of the national lumber associations. There

Vermont Timberland Owners Association Fire Look-
Station on West Pond Mountain, Ferdinand, Vermon

is a great variation of prices between the different grades of lumber which may be sawed from the same tree. The man who is able to grade his lumber and has enough of each grade to ship in car load lots derives a much higher price for the lot than he would if it were sold without grading, that is at one flat price.

Very few farmers cut enough logs in a winter, or have the use of the proper kind of mill, to take advantage of these factors. There is therefore a great temptation to sell the woodlot for a lump sum to the various mill men who are seeking such purchases. This of course is a bad practice because young growing trees are cut as well as large ones, and because the farm is left without any lumber for building purposes.

Every farm should have a well managed woodlot not only as an income producer but to supply wood and lumber for home use. The way to get the best results is to cut the trees as they become mature and remove the weed trees from time to time. By this

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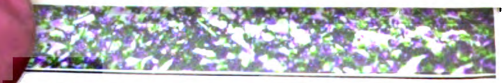
practice the farmer has a certain amount of woods work every winter thus utilizing his teams and men at a time when there would otherwise be no employment.

In order to get the benefit of better prices and at the same time improve the quality of the woodlots, it is necessary for several farmers owning small lots to co-operate in the harvesting. It is suggested that co-operative wood marketing associations may be formed after the pattern of cooperative creameries. Such an association should have control of at least one thousand acres of woodland in one main valley.

Like all new movements the formation of such an association must be worked out gradually and with great care. While different associations might be founded upon the same broad principle the local conditions would naturally determine the actual methods pursued.

In some places the association would simply act as a selling agent, having its lumber



nt Timberland Owners Association Fire Look-o
tion on West Pond Mountain, Ferdinand, Vermont.

custom sawed at the local mill; in other localities it would operate its own mill. In some cases special plants would be feasible, such as a box mill, turning mill, etc.; in others, as near large cities, the association might operate a wood yard and retail business. All of these matters would depend upon the supply of the various classes of lumber available, and the location.

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Offer of Vermont Forestry Department.

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As the first step toward the formation of such a co-operative association is a careful inventory of the material available, the Forestry Department makes the following offer:

Wherever through the county agent an informal association of land owners is effected having control of 1000 acres of woodlots or more, and applies to the state forester for a marketing study of the woodlots so controlled, he will make such a study upon conditions mentioned below. The study will

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include an inventory of the classes of lumber and wood available, and recommendations as to marketing the same. Special attention will be given to the question of the feasability of forming a co-operative marketing association; the amount of capital necessary, etc. The conditions are as follows:

(a) In case two or more applications are received by the State forester, the studies will be distributed in the several counties rather than in one county.

(b) The request for the study must be signed by the various land owners interested and be approved by the County agent. The signers are to express their intention of carrying out the recommendation of the marketing study, although they do not bind themselves to do so.

(c) Each signer of the application is to furnish board to the party of foresters (probably two or three men) while they are engaged in estimating his woodlots, and transport them to the next place to be examined.

Vermont Timberland Owners Association Fire Look-o
Station on West Pond Mountain, Ferdinand, Vermont

(d) The estimates in the reports will be total estimates of different classes of lumber and wood available for the whole association, or for individual watersheds. No estimates of individual woodlots will be given out except to those who guarantee to follow the recommendations of the report.

Application for Marketing Study.

We, the undersigned, hereby apply to the State forester for a marketing study of our woodlots.

The total area of woodlots owned by us is approximately..............acres, situated in the towns of..........................
in....................County.

It is understood that each signer is to furnish board to the party of. foresters while engaged in estimating his woodlot; and is to transport them to the next place to be examined.

It is our intention to put into practice the recommendations of the Study, and it is

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understood that individual estimates will be furnished only to those who guarantee to put these recommendations into practice.

Signed.

(Name) (Address)

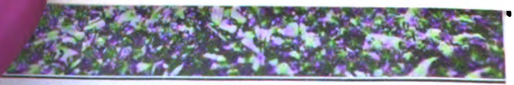
....

....

Approved County Agent of

....County..

Date..........................



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Station on West Pond Mountain, Ferdinand, Vermon

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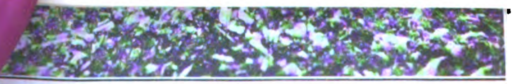

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VERMONT TIMBERLAND OWNERS' ASSOCIATION

1917 ANNUAL REPORT

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OFFICERS

H. G. PHILBROOK, President
Connecticut Valley Lumber Co.

E. E. AMEY, Vice President
Lancaster, N. H.

G. R. MONELL, Sec.-Treas., Forester
Bloomfield, Vt.

DIRECTORS

H. G. PHILRROOK,	Connecticut Valley Lumber Co.
C. C. WILSON,	Odell Manufacturing Company
W. R. BROWN,	Berlin Mills Company
A. N. BLANDIN	Deerfield Lumber Corporation
E. E. AMEY,	Lancaster, N. H.

FORESTER'S REPORT

The aim of the Vermont Timberland Owners' Association is to reduce to a minimum all danger from forest fires in the State by the establishment of a system of watch towers and patrol routes throughout the forested areas, by cooperation with State and Federal Governments and the Railroads, wherever possible, and by bringing to the attention of the general public the necessity for care with fires in the woods.

We have been very fortunate in the past two years in respect to forest fires. Unlike the Pacific Northwest, the past fire season in Vermont has been very favorable. In the Pacific Northwest, on an area not much over a hundred times that included in our Association, over 7,500 fires were reported during 1917. On this Association's lands in Vermont, during the same period, there was but one fire and that of little consequence,—only about a half acre being burned over.

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The year 1917 will certainly go down on record as the most favorable one from the standpoint of the absence of forest fires that Vermont has ever had. With the exception of about ten days in the early spring, there was practically no danger from forest fires during the entire season. Let us trust that 1918 will not compensate for the especially favorable seasons we have had for the past two years.

At the 1917 spring term of the Vermont Legislature, a law was passed abolishing the State Forestry Department and placing the work of that department under the Commissioner of Agriculture. At our 1917 annual meeting, the Association put itself on record as being opposed to this act and this is still our attitude. However, our relations with the State Department of Agriculture and their cooperation with us have been in nowise different or less effective than with the previous Department of Forestry. We hope to further extend our cooperative work with the Department of Agriculture during the coming fire season.

Our cooperation with the Grand Trunk Railroad has also continued and is working well. We hope to get better equipment for our railroad patrolmen, however, and there is no doubt but that inside of a few years, they will have gasoline speeders, so as to be able to follow up every train that goes through or near Association territory. We also hope to be able to get more railroads to cooperate with us in this way; and I want to take this opportunity to say to every timberland owner in the State, who owns land near a railroad right-of-way, that his lands should be listed in this Association, so that, all working together, we will soon be able to get the railroads to cooperate with us in keeping patrolmen on their lines, wherever and whenever there is any danger from fires.

There is a matter of vital importance to timberland owners of the whole country that is just recently demanding attention, and that is the danger from ravages of insects and plant diseases due to the importation of infected foreign plants and seeds. The enormous losses due to these causes are well known to all. The Hessian fly, the codling moth, the San Jose scale, the chestnut bark disease, the white pine blister rust, the brown-tail and the gypsy moths are perhaps the widest known, but there are hundreds of other pests that have been introduced into this country through infected nursery stock. A movement is being started to pass a law prohibiting the importation of all the natural carriers of these insects and diseases, except by the United States Department of Agriculture, who would take the correct measures necessary to remove all chances of infestation from such stock.

During the past year, the Association has erected about four miles of telephone line, giving us a total of about thirty-five miles of line. Because of the many wind and electric storms

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Practice Forest Conservation

RESULT OF FIRE ON CUT-OVER LANDS

by Fire Protection

Result of keeping fire out of cut-over lands

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An annual outlay of only

Not only is the tree growth wiped out, but also the productivity of the soil.

1c. an acre will patrol your lands

This growth will keep the soil in condition for a second growth of Softwoods ready to spring up when the Hardwoods are cut

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we had, our lines required continual attention during the past fire season. The State Department of Agricultre had no appropriation for telephone supplies for look-out stations, so the Association paid for the wire and insulators that were used on the Stratton Mountain line last year.

THE FIRE RECORD FOR THE PAST THREE YEARS

Year	No. of Towns Affected	No. of Fires	Total Area Burned	Average Area of Burns
1915	8	18	2,301	128 acres
1916	3	4	4	1 acre
1917	1	1	½	½ acre

The one fire that occured on Association territory during the 1917 season was along the Grand Trunk right-of-way, and it burned over only a small piece of timberland,—most of the area being inside the right-of-way fence.

ASSOCIATION PATROL

The Association had twelve men on patrol duty and one watchman during the past fire season, and most of these men were employed for only a part of the season.

Following is a list showing the routes of the patrolmen employed during the past year.

	ROUTE	TOWNS
1.	Grand Trunk Railway from Summit to Lake	Morgan, Warren, Grant, Norton
2.	East Branch of the Nulhegan River.	Bloomfield, Averill.
3.	Fitch and Guay Brooks and Granby Branch of Paul Stream.	Granby, East Haven, Ferdinand

4.	White River Valley.	Pittsfield, Chittenden.
5.	Tributaries of Winooski River.	Duxbury, Fayston, Huntington.
6.	Bourn Brook, Lye Brook and Winhall River.	Manchester, Sunderland, Stratton, Winhall.
7.	Grand Trunk Railway from Bloomfield to East Brighton.	Bloomfield, Brunswick, Wenlock.
8.	Black Branch of the Nulhegan River.	Avery's Gore, Lewis.
9.	White River Valley.	Hancock, Rochester.
10.	Moose River Valley.	Victory, Granby, East Haven.
11.	Deerfield River Valley.	Somerset, Stratton, Searsbury.
12.	Green Mountain Trail	Mendon, Goshen, Sherburne.

SECRETARY-TREASURER'S REPORT

January 1, 1917 to December 31, 1917.

RECEIPTS

Cash on deposit (January 1, 1917)	$ 1,214.48
Assessments for 1917 (¼ cent per acre)	1,689.02
	$ 2,903.50

EXPENDITURES

Patrol	$ 1,158.20
Telephone Account	
Service and tolls	34.61
Repairs	64.50
New line and apparatus	175.63
Advertising	37.30
Taxes	10.00
Office expenses	20.82
Traveling expenses	133.37
Deposited in Rutland Trust Company Bank	1,000.00
	$ 2,634.43
Cash on deposit (First National of St. Johnsbury)	$ 269.07
" " (Rutland Trust Co.)	1,000.00
Total carried over to 1918	$ 1,269.07

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1914.

The year 1917 will be remembered not only because of the most unusual weather conditions during the forest fire hazard season, but also because we were able to limit the assessments to ½ cent per acre for the year.

The Association has continued to use the telephone directory that is issued by the Coos Telephone Company as a medium for advertising. During 1918, we plan to extend our advertising to other telephone books, especially in the south western part of the State, where we are acquiring a large acreage under the Association. We want to extend the work of the Association to every acre of timberland in the State of Vermont, if that is possible. To accomplish this, we must acquaint every timberland owner in the State with the purposes and aims of our Association. During 1917 we have increased our listed area over 55,000 acres; we start 1918 with an increase of somewhat over 20,000 acres. Let us aim to add at least as much more before the year is over.

HELP PREVENT
FOREST FIRES

UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN No. 178

MARCH, 1914

Studies in Tolerance of New England Forest Trees

381882

BURLINGTON:
FREE PRESS PRINTING CO.,
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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 178: STUDIES IN TOLERANCE OF NEW ENGLAND FOREST TREES

I. DEVELOPMENT OF WHITE PINE SEEDLINGS IN NURSERY BEDS

By George P. Burns

In forest nursery practice, seedlings are usually raised in small seed beds arranged in numerous parallel rows. A separate frame is made for each bed, consisting of an open framework made of strips of lumber ⅞ inch thick and 2 inches wide, the entire frame being 12 x 4 x ⅔ feet. The sides are covered with a one-inch mesh wire netting and a strip of building paper, making the sides solid. Each frame has two tops, which are built of the same material as are the frames themselves. One is covered with a wire screen similar to that used on the sides, the other is covered with lath, laid close together forming a solid top. Only every other lath is nailed, thus leaving half of them loose for easy removal late in the season. The wire netting serves to protect seeds and seedlings against the birds, especially the English sparrows, which take almost every seedling.

When the two tops are in place and the paper is on the sides, the seedlings are contained in a space 12 feet long, 4 feet wide and 1 foot deep. The only openings are the small cracks between the lath and between the frame and covers. This condition, known as "full-shade" (plate II), differs of course from absolute darkness, but the light is very much reduced. Later on the loose laths are removed. The seedlings are then enclosed in a space with solid sides and half covered with lath. This condition is known as "half-shade" (plate II). In some nurseries the entire lath-covered top is removed toward the close of the summer, leaving only the wire screen. When this is done and the paper sides are left in place, the seedlings are contained in a box 12 feet long, 4 feet wide and 10 inches deep and are in a condition of "no shade" (plate II).

In most nurseries the side paper is removed early in the summer. The seedlings from thence onwards grow in a frame with wire top and sides. In other cases the alternate lath top is used as well as the wire top. In some nurseries the seedlings are thus protected for two years.[1]

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[1] The practice of removing the paper sides has been discontinued in the Vermont State Nursery. A series of trials made in 1911 shows that they had a very decided effect upon the meteorological conditions in the bed, especially on the amount of wind. In the center of the bed on the days during which the data were collected, the velocity of the wind was only 16 percent of that in the open or control station. Both anemometers were placed with the center of the cups 5 inches from the surface of the ground. The white atmometer of the Livingston type showed for the summer that the evaporation in the bed with solid sides was 44 percent of that in the control station. Clearly the paper sides are an important factor in checking water loss from seedlings.

The soil in the local nursery is level and very sandy. At seeding time it is thoroughly plowed and harrowed* before the frames are put in place. After placing the frames, 4 pounds of bonemeal are raked into each bed and the surface leveled. A few days before seeding most of the beds are treated with 1 percent formaldehyde solution and the full-shade top put in place. In a few cases dilute sulphuric acid was used as a fungicide. Each bed is well watered at seeding, and the soil firmly tamped and crowned 2 inches lengthwise. Fourteen ounces of white pine seed are sown broadcast, pressed firmly into the soil with a board and covered with sterile sand from an adjacent pit.[1] The two tops are replaced and the seeds left in full-shade for some time, at least until the period of germination is over.

There is much doubt in the minds of nurserymen as to the proper time to remove the loose lath or to remove the paper sides, and as to the length of time that the seedlings should be shaded. This bulletin seeks to throw light on these questions.

DAMPING-OFF

One of the chief difficulties of the forest nurserymen is the damping-off of the young seedlings. Some work has been done on its control at this station and elsewhere, especially by Hartley[5] and Spaulding.[10] It is not necessary in this connection to discuss in detail this phase of the nursery problem. Gifford[4] worked with several species and found in the Vermont State Nursery that "the damage may range from almost nothing to 90 percent of the stand, it being increased by warm weather following germination and by too much shading of the beds." He recommends the use of a "one-half to one percent solution of formalin used at the rate of three-fourths of a gallon per square foot." Hartley[5] used many fungicides and recommends for certain soils, "three-sixteenths of a fluid ounce of commercial sulphuric acid per square foot, applied in aqueous solution at the time of seed sowing, the beds to be watered sufficiently during the germinating period to prevent acid injury." Jones[8] recommends the application of hot sand and the removal of shades from both top and sides in beds in which the disease is found. It seems to be the general practice to attempt to control the malady by removing the solid sides and, sometimes, the top shade as well.

In further trials made at this Station, a bed was spaded July 29, 1911, and the west two-thirds treated with 36 gallons of a one percent formaldehyde solution. It was covered and left in full-shade. Eleven days later it was tamped, watered, seeded as shown in the accompanying diagram, and the solid lath top was replaced. The red pine germinated freely in a few days and was soon followed by the white pine and the Scotch pine in the order named. Excellent germination was obtained in all but the white pine areas where but few seed germinated until the following spring. Damping-off had begun by August 29th in the untreated area and all top shade was removed. The results on September 5th are shown in the following table:

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*This practice was adopted from the New York State nurseries and was suggested by State Forester Pettis.

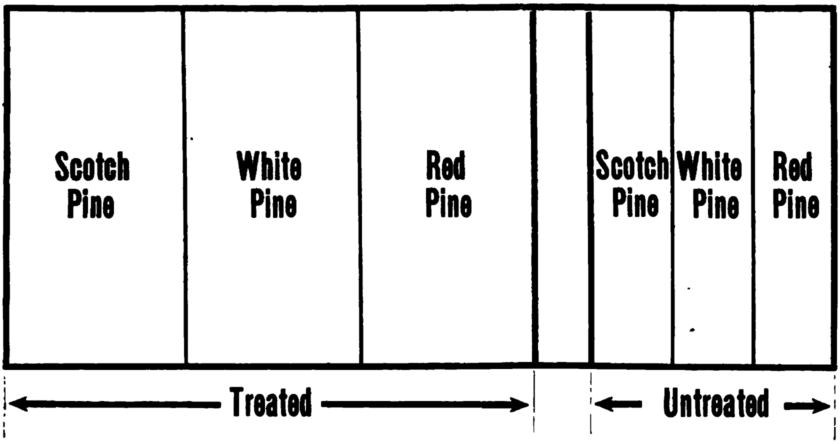


FIGURE 1—Plan of bed used in formaldehyde test, Nursery, 1911.

TABLE I—FORMALDEHYDE AS A FUNGICIDE

Species	Number of seedlings which damped-off Untreated area	Treated area
Red pine	1,655	13
White pine	8	0
Scotch pine	66	0

In contrasting these results it should be remembered moreover that the untreated area was only one-half as large as the treated area.

The past summer (1913) the west half of each of 12 beds was treated with dilute sulphuric acid, applied with a sprinkling can using 26 gallons of water and 4½ fluid ounces of commercial sulphuric acid for each 24 square feet. The application was made between 8 and 9 in the morning and the beds seeded that afternoon. The east half had been treated previously with a one percent formaldehyde solution. The untreated half was in each case given the same amount of tap water as the amount of solution applied in the treatment. No damping-off occurred. So far as could be judged the two treatments seemed equally efficacious.

These results seem to bear out those previously attained and to indicate that it is possible to control the disease with fungicides.

DEPTH OF PLANTING

White pine seeds are usually planted shallow, being barely covered with soil. In heavy soils when the seeds are too deeply covered the numerous young seedlings will sometimes raise large soil cakes, often many inches across, but in light soils this does not occur.

A series of trials were made to determine the proper depth for planting, as evidenced by the time required for germination and the number of seedlings obtained. This series was begun in the greenhouse in October, 1912, and a new bed was started every two weeks. Very poor germination was obtained in the early sown beds, although the external conditions for growth were favorable. Not until early spring did any large percent of seeds germinate in any of the sowings of October, November, December, etc.

All seed used were bought as Wisconsin seed of 1912. As soon as it was possible to secure satisfactory germination, three 4 x 4 feet beds were prepared. In the first bed the seed were barely covered, in the second they were covered to a depth of a quarter inch, and in the third to a depth of a half inch. In preparing the beds the greenhouse bench was filled with soil taken from the top 8 inches in the nursery. This was leveled and tamped in the usual way. A board a little wider than the bench was notched on both ends to a depth of one inch. Using this board it was possible to make a level seedbed exactly one inch below the edge of the sides of the bench. After thoroughly wetting the seedbeds, the seeds were sown on this level soil and firmly pressed into it. The first bed was covered with sand sprinkled on with a sieve thick enough just to cover the seed. No leveling was attempted. In the second bed the sand was put on with a sieve and was leveled by means of a board similar to the one used in leveling the soil before seeding, except that the notches were only three-fourths of an inch deep. In this way it was possible to cover the seeds exactly a quarter inch in depth. In the third bed the same method was followed, using a board with notches only a half inch in depth. All three beds were left unshaded and were subject to ordinary greenhouse conditions in a house where the principal crops were lettuce and radishes. All beds were watered regularly with a hand sprinkling can, each bed receiving the same number of gallons of water at each watering.

The following table shows the results in terms of the total germination at each date.

TABLE II—THE EFFECT OF DEPTH OF COVER UPON GERMINATION OF WHITE PINE IN THE GREENHOUSE WITHOUT TOP OR SIDE SHADE

Date	Number of seedlings Shallow cover	¼ inch cover	½ inch cover
January 21	2	7	8
January 28	10	23	25
February 10	24	54	62
February 14	31	73	97
March 1	41	102	147
March 11	44	126	209
March 17	45	171	287
March 19	45	189	340
April 1	46	270	502
April 14	46	319	721

These figures show that the germination under one-half inch of sand is almost sixteen times as great as under shallow cover and more than twice as great as under one-fourth inch cover.

A second and similar trial was made in the greenhouse. Three beds were prepared, sown, and covered exactly as those just described and, in addition, the usual nursery frame was put in place leaving the seeds in full-shade. The water applied at the time of sowing was all that was given the beds for some time.

TABLE III—THE EFFECT OF DEPTH OF COVER UPON GERMINATION IN THE GREENHOUSE WITH FULL-SHADE

Date	Number of seedlings Shallow cover	¼ inch cover	½ inch cover
April 21	9	35	21
May 5	35	167	662

The 167 seedlings in the second bed grew mostly around the south edge of the frame where the soil had a tendency to dry less quickly. The 662 seedlings from seed covered ½ inch deep were distributed evenly over the entire bed.

Apparently full-shade in the greenhouse has a tendency at first to equalize the effect of different depths of planting. Later, when no water was added, many more seeds germinated under the half inch of dust mulch formed by the sand used as cover.

In cases of shallow planting where the surface layer of soil was given sufficient moisture to prevent drying out, the number germinating was practically the same as in beds with deeper planting. The limiting factor is the water content of the layer of soil in which germination is taking place. An approach more or less nearly to the optimum in soil moisture may evidently be obtained either by relatively deep planting or by using shade.

Cannon[3] cites very similar results which were obtained by Bauer in experiments with Scotch pine. This author tried various depths of planting and recommends from 3-16 to 9-16 inch. The deeper planting delayed germination somewhat but the resulting stands were much better. Depths of more than 9-16 inch had a decidedly injurious effect upon germination.

NURSERY EXPERIMENTS

The practice in the state nursery for 1913 was based upon the results of these greenhouse trials and all seed were covered with sterile sand. In actual practice it proved impracticable to cover seed sown broadcast exactly a half inch deep. However, the attempt was made and while there was much variation in the depth of cover, all the seed were much deeper covered than is usual in nursery practice and were planted about a half inch in depth.

EFFECT OF LATH SHADE ON GERMINATION

On May 3rd, 5 beds, each 4 x 12 feet, were prepared as outlined previously, and treated with one percent formaldehyde solution. One was placed in full-shade, a second in half-shade, and the other three were left in no-shade. On May 7th the covers were lifted, the soil leveled, saturated with water, tamped, sowed with 14 ounces of 1912 Wisconsin seed, covered with a half inch of sterile sand and the shade-covers replaced.

The number of seedlings was counted on June 7th and June 12th with the following results:

TABLE IV—THE EFFECT OF COVER ON GERMINATION IN THE NURSERY BEDS

	Full-shade	Half-shade	No-shade			
			Bed No. 1	Bed No. 2	Bed No. 3	Average
June 7	7	5	38	21	47	32
June 12	206	850	1,935	2,228	2,112	2,092

No further counts were made; but such would have been much more favorable to the full-shade bed. Shading simply delayed the time of germination about two weeks. At the end of this time the seedlings came up very evenly and the resulting stand was about the same in all five beds. It was definitely shown, however, that in this case shading did not increase the number of seedlings produced, but it did give a somewhat more even stand.

A similar trial was made with a late instead of an early sowing. On June 2nd, 12 beds were prepared as usual. The east half of each bed was treated with formaldehyde, the west half with sulphuric acid as previously stated (page 128). The south half of the west 6 beds were sowed with German and the north half with Wisconsin seed. An attempt was made to cover the seed with a half inch of sterile sand. Solid board sides and a wire screen of the regular type were used, these beds being no-shade beds. Eleven of the beds were watered twice daily during June, usually for 3 minutes each, except on rainy days. The twelfth bed received no water other than the rainfall.

Germination was well started in all beds by the 19th. The seedlings came in large numbers in the 11 watered beds, but in the twelfth unwatered bed, only a small percent of the number obtained in the watered beds grew. The stand in the 11 beds was not a poor one, yet it was somewhat less uniform than in the no-shade beds of May 7th. This was evidently due to the depth of the cover. In places where the seeds were near the surface and the soil dried out quickly, few seedlings were found. On the other hand, seeds which were covered deeper germinated much better. In the twelfth bed not only did fewer seeds germinate, but the stand was very spotted. Seedlings came straggling along, a few at a time, all summer long. Probably a large number will appear this (1914) spring. The German seed showed slightly higher germination percentage than the Wisconsin seed.

The State Forester sowed 80 beds in the same nursery on the 24th of May. These were prepared the same way as those described, save that some were covered with burlap instead of adding the loose lath. All were treated with formaldehyde. Only 23 of them were kept under careful observation throughout the summer; 12 full-shade with solid lath covers and 11 full-shade with burlap. An even stand was obtained in each case. No difference appears as between those covered with laths and those covered with burlap. The stand was more even than in those trial beds sown June 2nd and left in no-shade, but certainly no better than in those of May 7th sown in no-shade.

For early planting during rainy weather the lath shade is clearly unnecessary to good germination and an even stand in the Vermont State Nursery; in fact it is detrimental in that it delays germination.

Atterberg[1] thoroughly studied the relation of light and temperature to the germination of pine seedlings and reviewed the older literature. He found that at a constant temperature of 23° C. in the absence of light, 80 percent of his seed germinated in 21 days, while during the same time at a constant temperature of 14° C. only 52 percent germinated. He considers 23° C. to be the optimum germination temperature. He planned another trial to determine the effect of light on germination. The temperature was kept at about 23° C. Seeds from the same lot as those used in the previous trial were kept in the light at this high temperature and at the end of 22 days 87 percent had germinated.

Apparently a high and changing temperature, light, and a moist seedbed are essential to satisfactory germination.

How do the lath shades affect the conditions of the surface soil in the seedbeds? In the 24 days following the sowing of May 7th, there were 18 days with sunshine, 15 days with rain or a trace of rain, and 9 days without rain. The average daily sunshine amounted to only 5 hours. The longest single period of sunshine occurred May 20th, and lasted 11¾ hours; the shortest period was 55 minutes on May 10th. Under these conditions the surface layer of soil at all times contained sufficient moisture for germination.

The average soil and air conditions during the 24 day germination period are displayed in table V, which shows that the soil temperature

TABLE V—TABLE SHOWING METEOROLOGICAL CONDITIONS DURING GERMINATION PERIOD OF SEEDS IN NURSERY BEDS

Summary: May 8 to May 31, 1913

Germination period, 24 days Averages	Full-shade	Half-shade	No-shade
Evaporation			
Black atmometer			
Day	3.2 cc.	7.9 cc.	12.4 cc.
Night	1.6 cc.	3.3 cc.	3.8 cc.
White atmometer			
Day	3.5 cc.	6.7 cc.	8.9 cc.
Night	1.7 cc.	2.9 cc.	3.3 cc.
Soil temperature			
Day	48.5° F.	49.8° F.	53.3° F.
Night	45.5° F.	43.9° F.	44.8° F.
Air temperature			
Day	45.6° F.	52.3° F.	55.3° F.
Night	42.6° F.	45.9° F.	49.4° F.
Humidity			
Day	74.9%	63.4%	62.4%
Night	81.6%	81.4%	80.3%

Number of days with sunshine	18
Number of days with rain, including only a trace	15
Number of days without rain	9

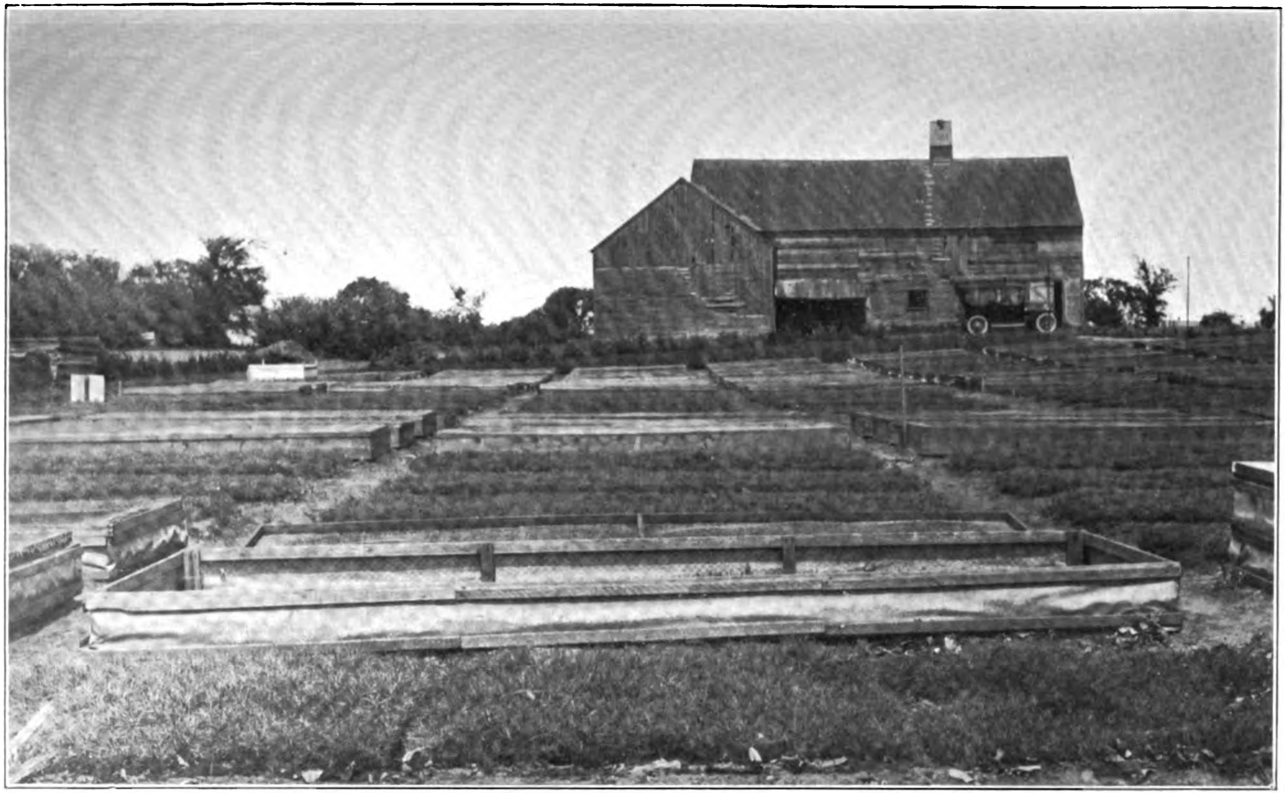


Plate I—A portion of State Nursery No. 1 for Forest Seedlings, on grounds of the University of Vermont.

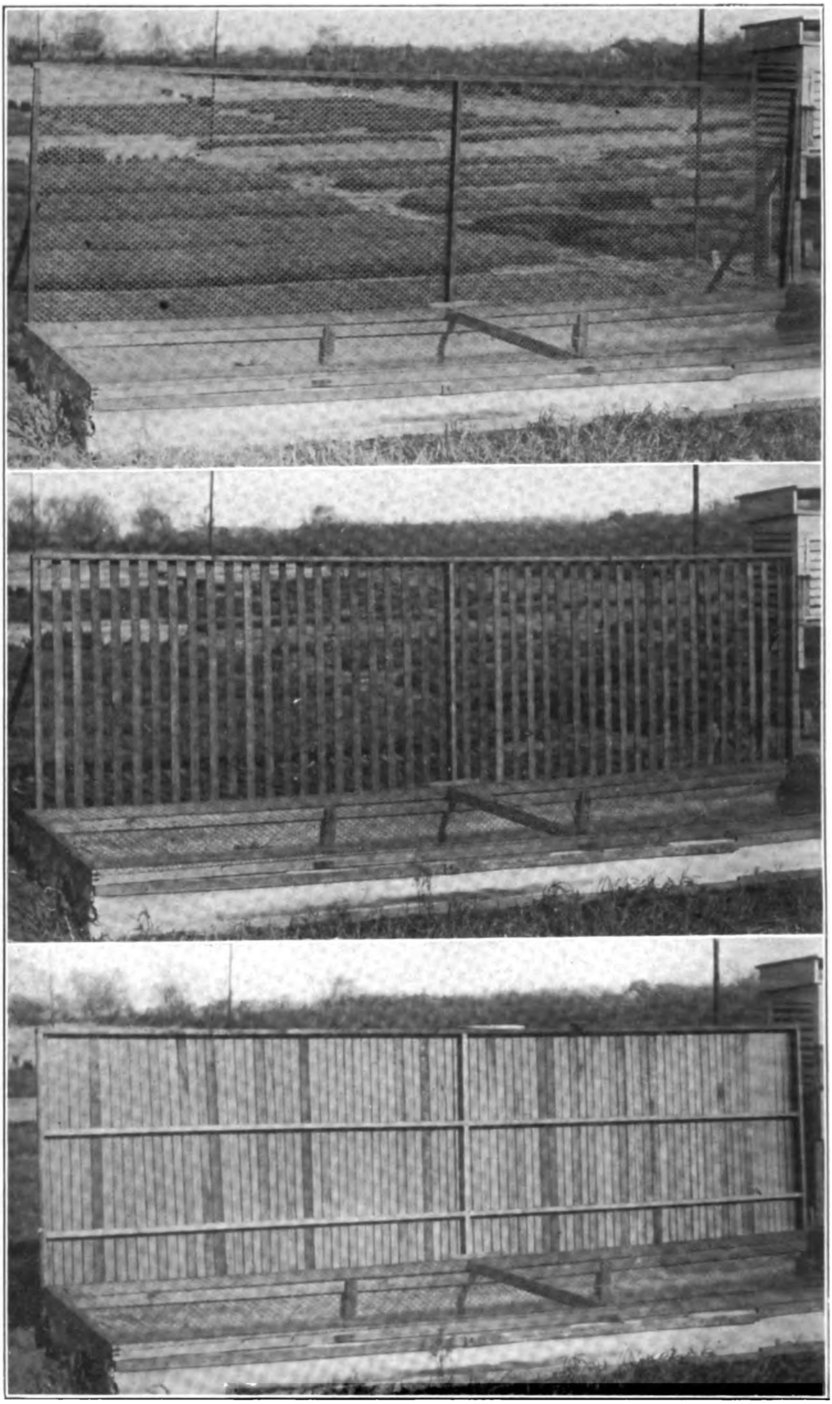


PLATE II—No-shade, half-shade and full-shade beds for forest seedlings: with covers raised.

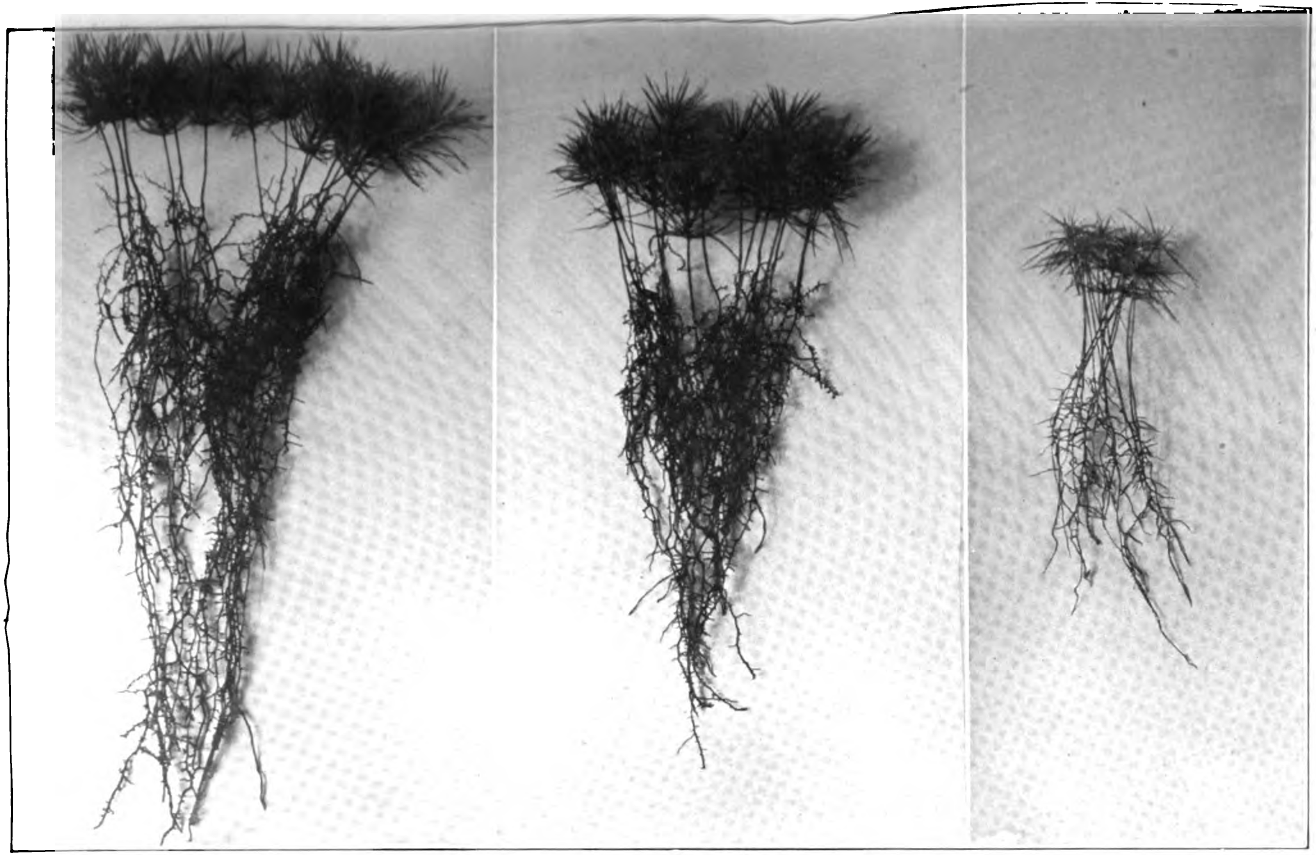
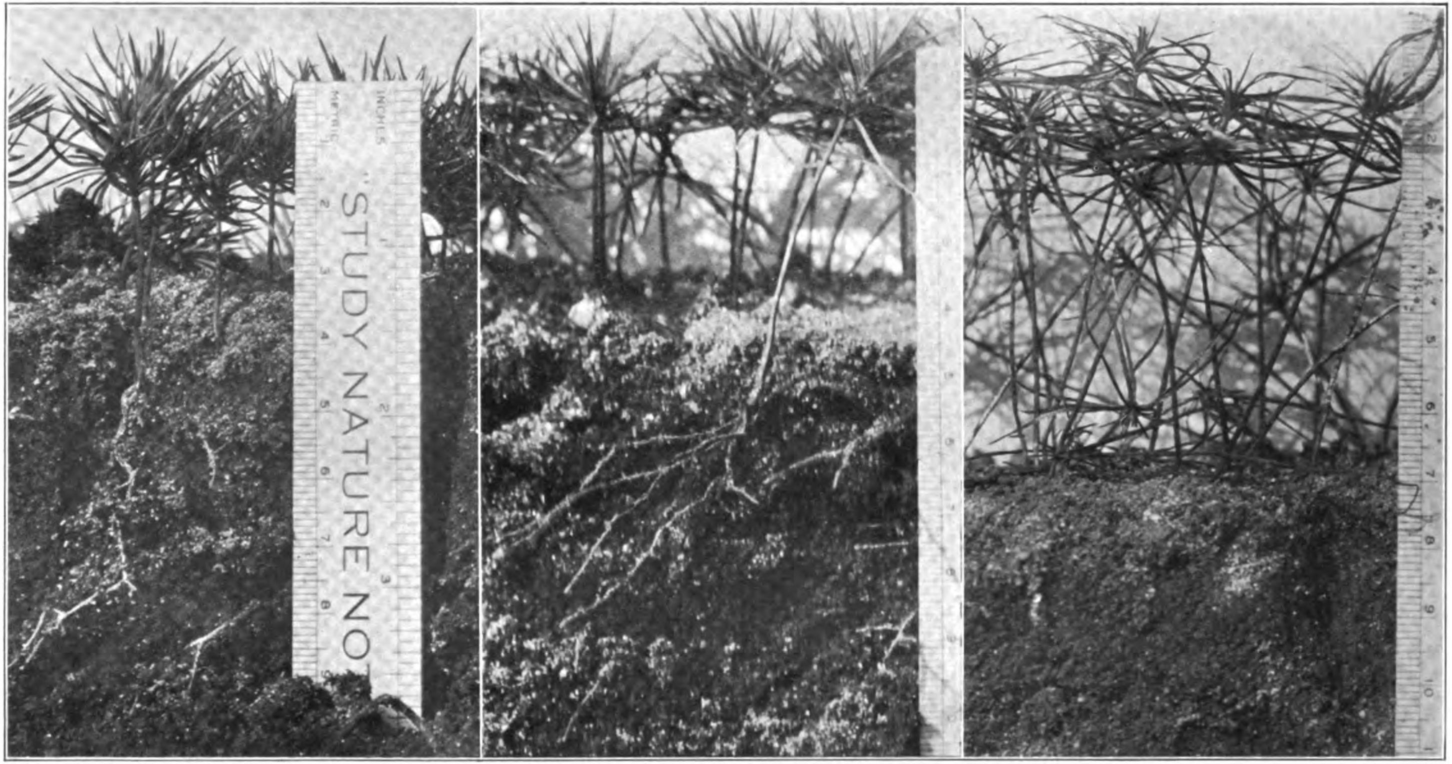


Plate III—Fifteen seedlings, no-shade. Fifteen seedlings, half-shade. Fifteen seedlings, full-shade.
Photographed October 24, 1913, 5½ months old.



No-shade. Half-shade. Full-shade.

Plate IV—1912 seedlings photographed in April, 1913.

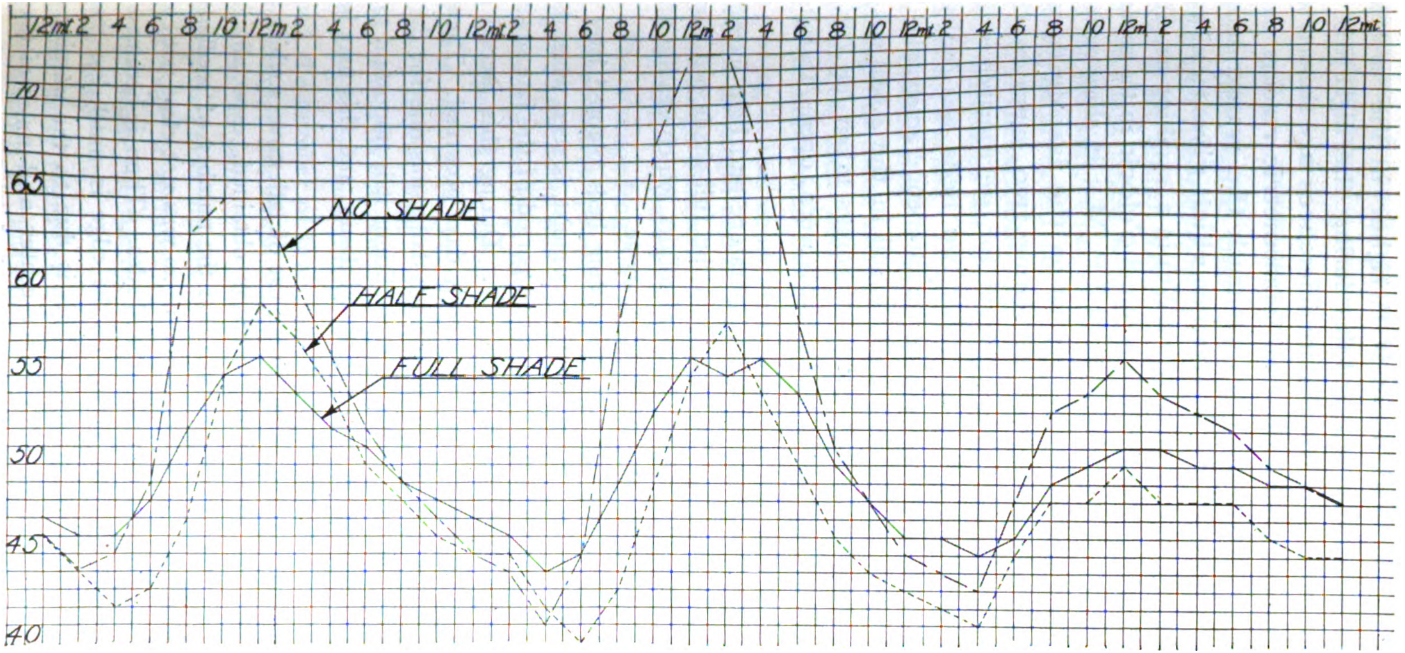


Figure 2—The effect of shade upon soil temperature, one inch below the surface. Record made May 25-27, 1913.

for the 12 day hours was about 5° F. higher in the "no-shade" bed than in the "full-shade" bed; and that during the night period it was about 1° F. lower. The temperature differences are shown to best advantage when one studies the actual thermometric readings. On sunny days the soil in the no-shade bed was much the warmer, in one case the difference being 20° F. The diagram which gives the soil temperature readings for May 25th, 26th and 27th is a striking one. The first day the sun began shining a little before 8 o'clock in the morning and continued with only short breaks until 2 P. M.; it shone continuously for 11½ hours on the second day; but on the last day the sun was hidden. This diagram shows that during two sunny days the soil temperature was close to the optimum for germination in the no-shade bed, while the soil in the other two beds was decidedly below the optimum. On the second day the difference amounted to 18° F.

The amount of light falling on the soil in the 3 beds was determined with a Clement's photometer Readings taken July 27th, 1911, show that the light intensities in the 3 beds were: open .715, half-shade .359, and full-shade .025.

Clearly the conditions of soil temperature and light intensity are much less favorable for germination in the full-shade bed than they were in its competitors, a condition of affairs which readily accounts for the delay in germination recorded above.

The necessity for watering or shading beds planted later in the season in order to keep the surface layers moist, is seen when the conditions obtaining during the germination period of the late sowing are compared with those shown in table V. During this second period of 24 days no rainy and only two cloudy days occurred. There were 22 days of sunny weather. The average daily sunshine for the entire period was 8⅔ hours. Under such conditions it is important to adopt some method of keeping the surface soil damp; and this may be done either by shading or watering.

One trouble is often found in the use of lath covers which causes a decrease in the number of seedlings obtained, especially in late sowings. It is commonly observed that the number of seedlings near the edges is small. Why this should be so was not clear until a study was made of the rainfall under the shades. Then it became evident that the amount of water falling on the edge is much less than that falling in the center of the bed. This is due to the warping of the lath. These sink considerably in the center and much of the water falling on the lath runs toward the center before falling to the ground.

The number of seedlings produced and the character of the stand seems dependent mainly on the moisture content in the surface soil layers.

DEVELOPMENT OF SEEDLINGS

Several greenhouse trials were started to determine the effect of shading upon the development of the seedlings. A bench section was seeded in the usual way with white pine seed. One section was covered with a box lined with black paper, inverted over the seed and pressed into the soil, thus excluding all light. A second plot was covered with an inverted box the bottom of which had been replaced with a layer of cheesecloth. An adjacent plot acted as a control.

Great differences in the appearance of the seedlings were evidenced within 3 weeks. Those grown in darkness were tall, pale green and easily knocked over. Many hypocotyls were 12 cm. long, and the average length of those measured was 9.1 cm. The roots were short and unbranched, their average length being 2.5 cm. A striking example of the differences between root and hypocotyl development of plants growing in this condition is seen in a case where the hypocotyl was 12.5 cm. in length and its root only 2.5 cm. in length.

The seedlings produced in partial shade under the box with solid board sides and a cheesecloth cover were much shorter and darker green. The average length of the hypocotyls of the considerable number of representative specimens measured was 4.38 cm., and the average length of the roots was 3.61 cm.

The control seedlings were much shorter and sturdier than those found in either of the other two beds. The average length of hypocotyl was only 2.44 cm., while the average taproot for the same plants was 7.63 cm. long. Another striking difference was observed in these roots. While none of the plants grown in dense or partial shade developed any lateral roots, those grown in the control were freely branched, the number of branches varying from 3 to 6 and averaging 5. The average additional length of the root system due to lateral branches was 5.3 mm.

Clearly darkness induces the growth of tall seedlings with poorly developed roots; a diffused light, the growth of shorter plants and longer roots; while the full light produces short stalky plants with long branching roots.

Halsted[7] lately published a preliminary study of the elongation of the hypocotyl which is "introductory to the study of the elongation of the hypocotyl in its relation to successive generations of offspring secured through selection and breeding." He emphasizes the many factors which may influence the hypocotyl growth, such as variations in individuals produced by different plants, maturity and size of seed, depth of planting, soil moisture, humidity of the air, light intensity, temperature, etc.

In the work herein reported, it was not necessary to determine what influence each of the factors had on the outcome. The results show the response of the plants to the combination of factors under which they developed.

A similar study was made of seedlings growing in the nursery under full-shade, half-shade and no-shade. On July 18th, 1912, 100 seedlings from each of these 3 beds were dug, care being taken to secure in each case all of the root-system. These were taken to the laboratory, washed and measured. The results are shown in the following table.

TABLE VI—TABLE SHOWING RESULTS OF SHADE ON THE LENGTH OF HYPOCOTYL AND OF ROOT SYSTEM

Full-shade		Half-shade		No-shade	
Hypocotyl cm.	Taproot cm.	Hypocotyl cm.	Taproot cm.	Hypocotyl cm.	Taproot cm.
8.0	4.1	4.8	4.5	3.5	4.9
7.9	4.7	4.8	4.0	3.5	3.8
7.7	4.5	4.7	6.5	3.4	5.7
7.2	3.7	4.7	3.6	3.4	5.7
7.2	3.6	4.3	5.0	3.3	4.1
7.2	3.6	4.3	4.8	3.2	6.8
7.1	4.6	4.3	4.7	3.2	6.0
7.0	4.6	4.3	3.8	3.2	4.7
7.0	3.6	4.2	4.2	3.1	4.7
7.0	3.4	4.2	4.0	3.1	4.3
7.0	3.0	4.2	3.6	3.0	8.0
7.0	2.9	4.1	2.8	3.0	5.8
6.9	2.7	4.1	4.9	3.0	5.7
6.9	2.6	4.1	4.5	3.0	5.4
6.8	3.3	4.1	4.3	3.0	5.3
6.8	3.2	4.0	2.4	3.0	4.9
6.8	2.8	4.0	6.2	3.0	4.8
6.7	4.7	4.0	6.0	3.0	4.7
6.7	4.5	4.0	6.0	3.0	4.6
6.7	4.0	4.0	5.4	3.0	4.3
6.7	3.0	4.0	5.3	3.0	3.8
6.7	2.8	4.0	4.7	3.0	3.3
6.6	4.6	4.0	4.6	2.9	6.6
6.6	3.3	4.0	4.2	2.9	5.7
6.6	2.5	4.0	4.1	2.6	3.5
6.6	2.4	4.0	4.0	2.5	8.2
6.5	4.5	4.0	3.7	2.5	6.7
6.5	3.8	4.0	3.7	2.5	6.6
6.5	3.5	3.9	4.5	2.5	5.8
6.5	3.4	3.8	7.0	2.5	5.7
6.4	4.1	3.8	6.1	2.5	5.6
6.4	2.8	3.8	4.0	2.5	5.0
6.3	2.6	3.8	3.4	2.5	5.0
6.2	4.5	3.8	3.3	2.5	5.0
6.2	4.1	3.8	3.2	2.5	4.8
6.2	3.3	3.8	3.1	2.5	4.6
6.1	3.8	3.8	3.1	2.5	4.6

TABLE VI—CONTINUED

Full-shade		Half-shade		No-shade	
Hypocotyl cm.	Taproot cm.	Hypocotyl cm.	Taproot cm.	Hypocotyl cm.	Taproot cm.
6.0	4.9	3.8	3.0	2.5	4.5
6.0	3.7	3.7	5.2	2.5	4.2
6.0	3.6	3.7	4.2	2.5	3.8
6.0	3.5	3.7	4.0	2.5	3.7
6.0	3.3	3.7	3.3	2.5	3.6
6.0	3.2	3.7	3.1	2.5	3.6
6.0	3.2	3.7	2.6	2.5	3.5
6.0	3.2	3.6	5.5	2.4	7.5
6.0	3.1	3.6	3.8	2.4	6.7
6.0	3.1	3.6	3.1	2.4	4.9
6.0	2.8	3.6	3.1	2.4	4.8
5.8	5.2	3.5	7.0	2.9	5.1
5.8	4.0	3.5	6.8	2.8	8.8
5.7	5.0	3.5	6.8	2.8	7.8
5.7	3.9	3.5	5.8	2.8	6.0
5.7	4.0	3.5	5.3	2.8	5.3
5.7	3.5	3.5	5.2	2.8	4.8
5.6	3.7	3.5	5.2	2.8	4.8
5.6	3.6	3.5	4.5	2.8	4.6
5.6	3.2	3.5	4.4	2.8	4.6
5.6	3.0	3.5	4.2	2.8	4.5
5.6	3.0	3.5	3.5	2.8	4.5
5.6	2.8	3.5	3.1	2.8	4.5
5.6	2.6	3.5	3.0	2.8	3.2
5.6	2.5	3.5	3.0	2.7	5.6
5.5	4.5	3.5	2.9	2.7	5.2
5.5	4.1	3.4	7.0	2.7	5.0
5.5	4.0	3.4	6.4	2.7	4.7
5.5	3.5	3.4	5.2	2.7	4.3
5.5	3.3	3.4	4.4	2.7	3.5
5.5	3.3	3.4	4.2	2.6	7.2
5.5	3.1	3.4	3.1	2.6	7.1
5.5	3.0	3.4	4.2	2.6	5.7
5.5	3.0	3.3	3.8	2.6	4.7
5.5	3.0	3.3	3.5	2.6	3.7
5.5	2.6	3.3	2.8	2.4	4.3
5.4	4.2	3.3	2.8	2.4	3.0
5.3	4.5	3.2	6.0	2.3	8.2
5.3	3.8	3.2	5.8	2.3	6.5
5.3	3.6	3.2	3.5	2.3	6.0
5.3	3.3	3.2	3.4	2.3	6.0
5.3	2.5	3.2	3.3	2.3	5.8
5.3	2.1	3.2	2.8	2.3	5.8
5.2	4.5	3.1	3.5	2.3	4.8
5.2	4.0	3.1	3.2	2.3	4.2
5.2	3.2	3.0	6.6	2.3	3.6
5.2	3.1	3.0	6.5	2.2	6.5
5.2	3.0	3.0	6.0	2.2	5.3
5.2	2.7	3.0	5.4	2.2	5.0
5.0	4.6	3.0	4.6	2.2	4.7
5.0	4.4	3.0	4.5	2.2	4.0
5.0	3.6	3.0	4.5	2.2	3.8
5.0	2.8	3.0	4.3	2.0	6.8
5.0	2.8	3.0	4.0	2.0	6.5
5.0	2.7	3.0	3.3	2.0	5.8
5.0	2.4	3.0	3.2	2.0	5.4
4.9	3.4	3.0	3.1	2.0	5.3
4.8	4.2	2.8	5.4	2.0	5.2
4.8	3.8	2.7	4.8	2.0	5.0
4.8	3.8	2.7	4.4	2.0	3.6
4.8	3.5	2.6	7.1	2.0	3.4
4.5	3.5	2.5	3.7	2.0	3.2
4.2	3.0	2.4	3.6	2.0	2.8

TABLE VI—CONTINUED

	Full-shade Hypocotyl cm.	Full-shade Taproot cm.	Half-shade Hypocotyl cm.	Half-shade Taproot cm.	No-shade Hypocotyl cm.	No-shade Taproot cm.
Averages	5.94	3.52	3.6	4.17	2.62	5.19
Average length of lateral roots		.00		.036		.235
Total root system		3.52		4.506		5.425

On August 7th a similar study was made of 50 seedlings from the nursery and the following results were obtained.

TABLE VII—TABLE SHOWING RESULTS OF SHADE ON LENGTH OF HYPOCOTYL AND OF ROOT SYSTEM

	Full-shade	Half-shade	No-shade
Average length of hypocotyl..........	5.6 cm.	3.35 cm.	2.5 cm.
Average length of root system.......	4.6 cm.	8.25 cm.	13.8 cm.
Number of lateral branches	5	143	468
Number plants with lateral branches..	3	40	49

Nikolsky[9] experimenting with pine and spruce secured similar results. With one year old plants "the greatest length of stem was found in shaded rows; the length of the main root, as well as the number and total length of the lateral roots, however, diminished with increase in shade, while the total length of all roots in rows with great light intensity was greater than the total length of all roots in shallow rows, in pine seven and a half times."

Plate III illustrates the results which were obtained. Fifteen plants were dug from each of the beds. The photographs were taken at equal distances and hence comparisons may be made.

The seeds were sown May 7th and the plants dug and photographed Oct. 24, 1913. A great difference in development is shown in the root system as seen in the length of taproot, richness of lateral branches, and in the presence of mycorhizas in the no-shade and half-shade beds only. A second difference is to be noted in the development of the tops. In the full-shade plants, little more has occurred than the unfolding of the cotyledons. The photographs show much greater development in the no-shade and half-shade plants.

Plate IV betrays the conditions of the 1912 seedlings after passing the winter without protection. The lath cover was removed from the full-shade bed late in the fall. The picture of full-shade seedlings does not represent conditions accurately. Only a few seedlings could be found in the entire full-shade bed; the vast majority had died during the winter. No loss had occurred in the other two beds. The camera was placed at exactly the same distance in each case.

The differences in seedling development under the three conditions can be further illustrated by a study of the diameter growth of the hypocotyl. The next table gives the measurements of ten seedlings from each experimental bed. The hypocotyl of the plants grown in full-shade have a diameter of only 58 percent and those grown in half-shade of only 78 percent of that of plants grown in no-shade.[1]

TABLE VIII—THE MEASUREMENT OF HYPOCOTYL DIAMETER OF SEEDLINGS

	Full-shade mm.	Half-shade mm.	No-shade mm.
	.80	1.00	1.00
	.70	.85	1.54
	.70	1.04	1.00
	.62	1.18	1.00
	.79	1.08	1.20
	.68	.90	1.33
	.69	.95	1.60
	.82	.95	1.25
	.71	.90	1.30
	.69	.85	1.15
Averages	.72	.97	1.24

CHEMICAL COMPOSITION

On July 31st, 1,000 seedlings from the full-shade bed and 500 from each of the other two beds were carefully dug. A much larger number with a ball of dirt was taken from the bed with a spade and the seedlings washed out with a stream of water. In this way, the entire root system of each seedling was secured. The leaves were cut off just below the cotyledons, the two parts of the plant were weighed separately and oven-dried. The results of a chemical study are shown in the following table.

TABLE IX—COMPOSITION OF SEEDLINGS AND RELATION OF TRANSPIRATION TO ABSORBED SALTS

Bed	Number of plants	Average green weight in grams	Average dry weight in grams	Average amount of ash in grams	Ash in percent of dry weight	Nitrogen percent	Amount of water transpired
No-shade	500	.304	.063	.0052	8.29	2.18	21×
Half-shade	500	.166	.034	.0032	9.35	2.7	9×
Full-shade	1,000	.09	.010	.0010	10.20	6.89	×

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[1] Ample material for a study of the comparative anatomy of seedlings grown under the experimental conditions discussed has been preserved and such a study is under way.

The average green weight of the plants in the no-shade bed was almost twice that of those grown in the half-shade bed and a little less than four times that of those grown in the full-shade bed. The differences in dry weight were yet more marked. The dry matter grown in the no-shade bed was almost twice as great as that grown in the half-shade bed and six times more than that grown in full-shade bed.

Variations occurring in the actual amount of ash are shown in the fourth column. The ash content is displayed in the fifth column stated in terms of percentage of dry weight. The average ash content in the plants in the no-shade bed is over five times as much as that in the plants of the full-shade bed; but the latter are richer in the percentage of ash. Clearly the shade afforded by the lath-cover causes an increase in the percentage of ash in white pine seedlings.

The nitrogen contents figured on the dry matter basis for the three beds show a slight but significant increase in nitrogen when the half-shade plants are compared with the no-shade crop; those grown in full-shade, however, carry more than twice as much, the conditions under full-shade being more favorable to an accumulation of nitrogen in the plants thus grown.

The last column shows the results of trials made during the past summer and published in a later bulletin, to determine the amount of water transpired by white pine seedlings in the three beds under consideration. The summary of the work shows that about 21 times as much water was transpired from seedlings in the no-shade bed as was given off from those in the full-shade bed and 9 times as much from those in the half-shade bed as from those in the full-shade bed.

What is the relation of transpiration to the amount of absorbed salts? Comparing the figures showing the amount of ash in seedlings grown under the three conditions of the experiment with the amount of water which was transpired by these seedlings, it is seen that an increase in the amount of water transpired is not accompanied by a proportional increase in amount of ash absorbed from the soil. Plants in no-shade transpire about 21 times as much water as those growing in full-shade and yet they contained only a little over 5 times as much ash. The same principle holds true if plants growing in half-shade and full-shade are compared. That is to say, plants are able on dry, hot, sunny days to absorb water which is much weaker in salts than is the soil solution. This absorption of large amounts of water is a protective function and the distribution of salts is a secondary consideration. These plants seem to be able to absorb sufficient mineral matter even when transpiration is very greatly reduced.[1]

Hartley[6] emphasizes the importance of sun scorch as a nursery trouble. Seedling death from this cause is due to the excessive amount of transpiration from the young needles which causes them to dry up. No trouble, which has been recognized as such, has been experienced with seedlings in this nursery, except when the full-shade was removed from seedlings on sunny days. Under such circumstances it was quite common for the cotyledons to turn brown. No sun scorch occurred in plants that were unprotected or were kept in half-shade since germination. These plants have a better developed epidermal system than those grown in the shade. Sun scorch may be produced in a 2 or in a 3-year old white pine if it is shaded during the early spring and the shade is suddenly removed in the summer. It is a matter of transpiration, and, as the development of the epidermal system is influenced unfavorably by shading, the least possible amount of shade should be given during the periods of germination and early development of the leaves.

Stone,[11] who has studied sun scorch in older white pine trees, finds that this injury is due to the death of part of the root system by winter killing. This misfortune makes it impossible for them to furnish a sufficient supply of water during the warm and windy days of summer. That this does not factor in the nursery beds is evident. The root systems are not injured in any way, and yet plants from which a comparatively heavy shade was suddenly removed showed sun scorch. The occurrence, as has been said above, must be correlated with the structure of the leaf.

SUMMARY

The following conclusions seem applicable to conditions in the Vermont State Nursery:

(1) Damping-off of white pine seedlings can be controlled by the use of formaldehyde or sulphuric acid.

(2) In sandy soils, seed should be planted not less than one-half inch deep.

(3) If seed is sown early in wet weather, no top shade is needed to get an even stand.

(4) If seed is sown late in dry weather, the surface soil must be kept moist by watering or by full-shade top.

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[1] A general discussion of the relation of transpiration to the ash content of plants with literature review will be given when further trials now under way are completed.

(5) Shade reduces the temperature of the soil and delays the time of germination.

(6) After the period of germination, all shade should be removed because it hinders the development of the seedlings.

(7) The solid sides should be left in place the first season as they greatly decrease the loss of water by transpiration.

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FEBRUARY, 1916 BULLETIN 193

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

STUDIES IN TOLERANCE OF NEW ENGLAND FOREST TREES

III. DISCONTINUOUS LIGHT IN FORESTS

by G. P. BURNS

(Vermont forestry publication 20)

1791

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FORESTRY
COLLEGE OF AGRICULTURE
UNIVERSITY OF CALIFORNIA

BURLINGTON:
FREE PRESS PRINTING CO.,
1916.

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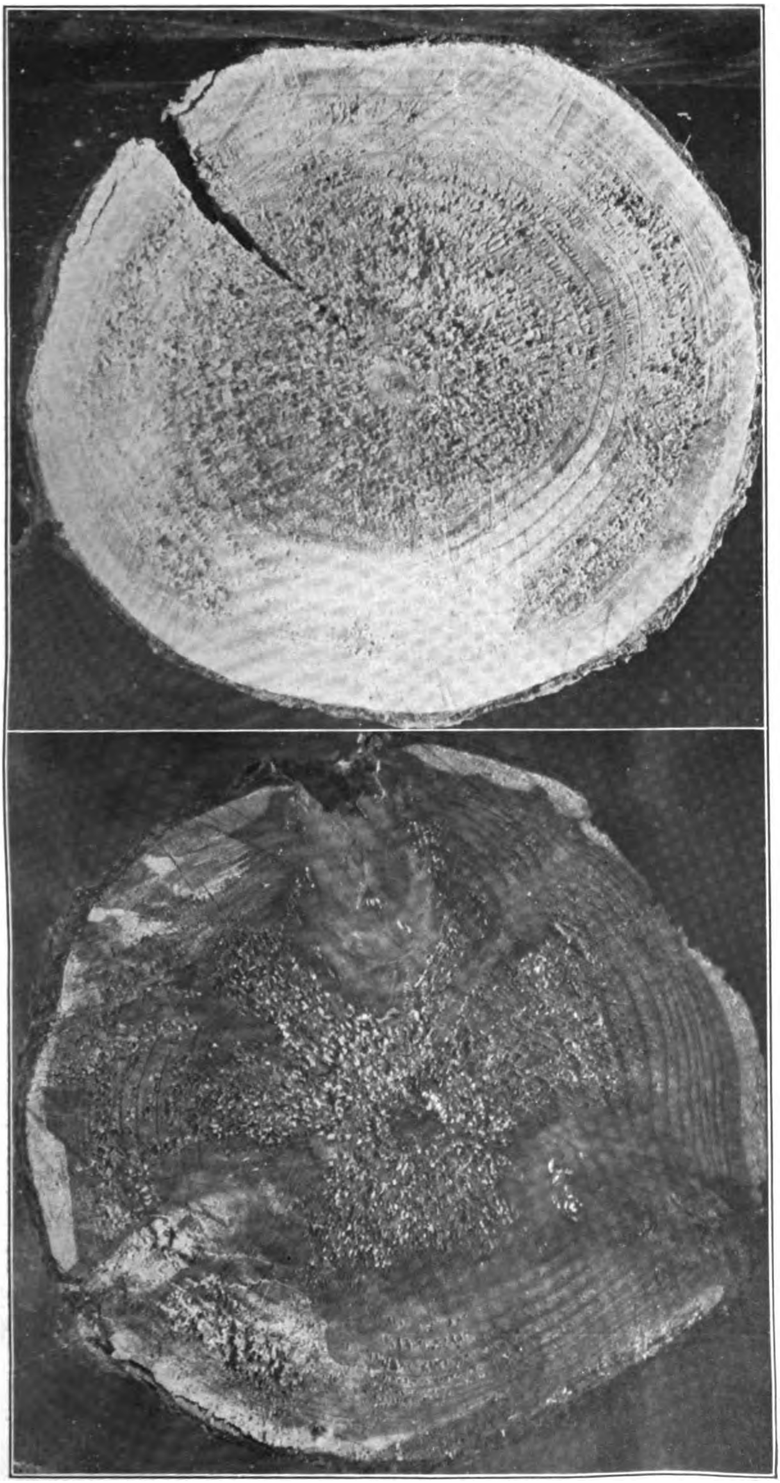

Plate I. Cross section of eight-inch pine showing permeation of sap-wood by the fungus (upper). Cross section of diseased pine (lower).

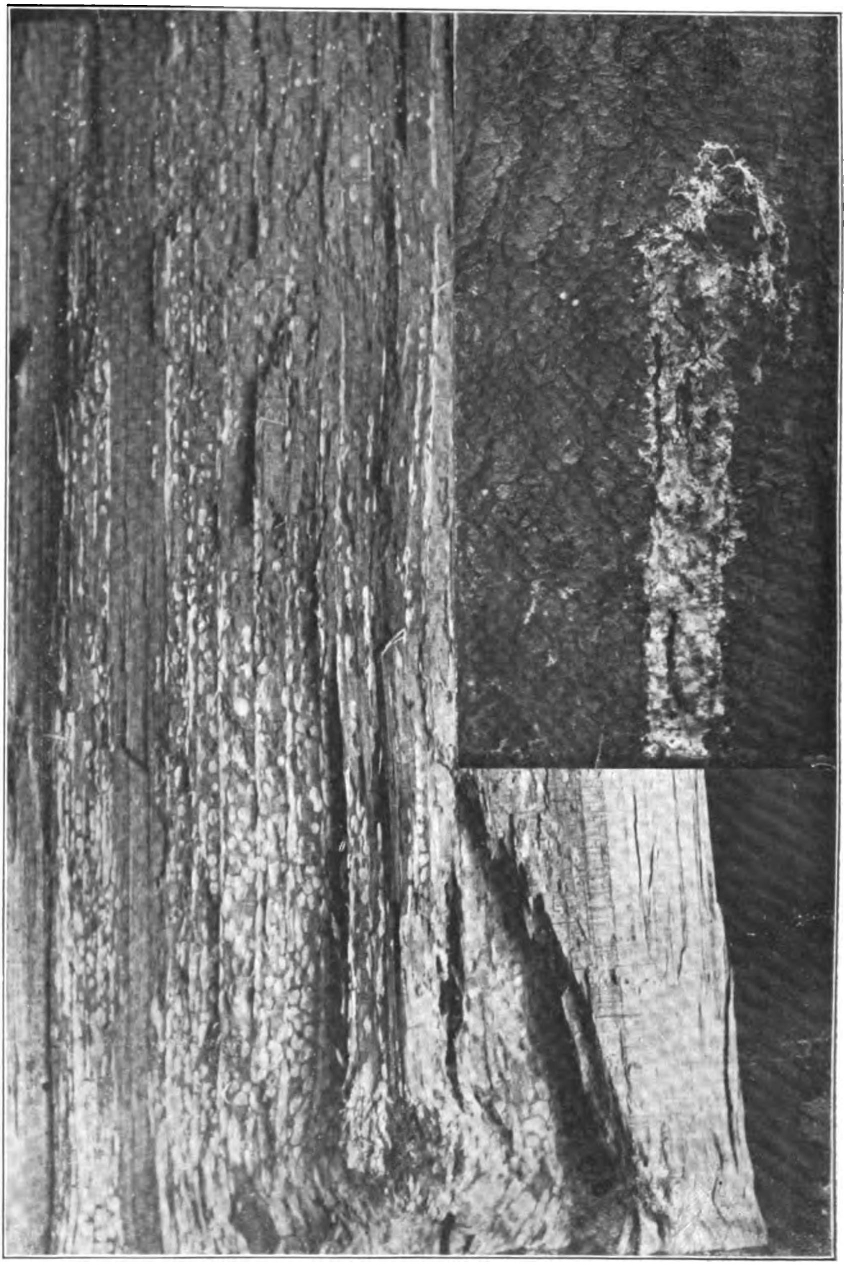

Plate II. Longitudinal section of pine showing appearance of infected wood (main view). Fruiting body of *Trametes Pini* on a fourteen-inch pine, together with pitch exudate below fruiting body (in upper right hand corner).

BULLETIN 191: THE RED ROT OF CONIFERS

By F. H. Abbott[1]

SUMMARY

The so-called red rot of conifers is caused by the fungus *Trametes Pini,* which is primarily a parasite, assuming more or less the characters of a saprophyte when the tree falls. The fungus commonly attacks five species of conifers: tamarack, pine, hemlock, spruce and balsam. Its ravages are greatest in unthinned stands, especially pure stands of white pine.

Infection occurs mainly through broken branches which expose the heart-wood. Root infection is doubtful. Sporophores are the principal means of spreading the disease. They form on all host species but vary in form from an incrustation on the spruce and balsam to a bracket or hoof on pine and tamarack. They exist on both standing and falling trees. The mycelium spreads more rapidly up and down the trunk than across it. The damage to the wood is wrought by the solution of its lignin content by the enzym of the fungus. This damage appears to cease when the tree falls.

Laboratory cultures of the fungus from various sources exhibited uniformity. Spores were not produced in the cultures, at least up to six months. Successful cultures may be made on sterile wood.

Prevention is best effected by proper thinnings, removing diseased trees and destroying fruiting bodies.

The weight, breaking and crushing strengths of the woods were decreased approximately in proportion to the permeation of the wood by the fungus.

The red rot of conifers damages Vermont timber owners annually to the extent of about a quarter of a million dollars. The diseased wood is used in the manufacture of boxes, tubs, wooden pails, etc.

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[1] The writer expresses his appreciation of the assistance he has received from Arthur S. Graves of Yale University, B. A. Chandler of the Vermont Forestry Department and from the Station Forester and Plant Pathologist in assembling the data and in preparing this paper. The collection of references was facilitated through the assistance of Perley Spaulding of the United States Department of Agriculture. Valuable specimens were contributed and field observations made by Mr. Chandler. The collection of the data regarding losses in the mills and woods was accomplished only through the cordial cooperation of landowners, millowners and operators. C. G. Hedgecock of the United States Department of Agriculture also assisted in the identification of sporophores and diseased wood.

I. FINANCIAL LOSSES

According to the 1910 census report, reviewed by the United States Forest Service in Vermont Forestry Publication No. 11, "Wood Using Industries of Vermont," Vermont produces lumber, lath and shingles from pine, spruce, hemlock, tamarack and fir, totaling 194,273,000 board feet. Were this all sound timber, free from red rot and other defects, it would average at the mill $20 per thousand square edged. As a result of the writer's inspection of lumber in twenty mills and yards in various parts of Vermont in the spring of 1913, it is estimated that on account of the red rot nine percent of this total is reduced to a grade worth approximately $10 per thousand. In other words, on a total of 17,484,570 board feet of timber affected by red rot, there is an annual loss of $174,845.

But this is not all. These figures are taken at the mills and shipping points and do not represent the lumber before it is marketed. Much of the timber—calculated, from observation in the woods and estimates by lumbermen, at 2 percent of the actual cut in the woods—is so badly diseased with red rot as to be entirely useless. This, of course, never is hauled from the stump. Basing the calculation on the census figures and for the total output, this absolute loss of 2 percent totals 3,885,460 board feet. Sound logs to this amount would be worth in the woods approximately $25,000. In addition to these losses there is the great loss to trees which become diseased and are dying constantly in the forests, eventually falling to the ground and rotting. The total annual loss to Vermont timber owners due to the red rot disease, therefore, may be placed approximately at a quarter of a million dollars.

The percentages used in this calculation were averages taken from data collected in person by the writer from actual mill tallies, observations and quarter-acre circle tallies made in the woods, and from figures and estimates furnished by mill owners and operators throughout northern Vermont.

Investigations made by the writer indicate that in white pine lots there was a loss of 8 percent of value due to the disease; in pure spruce 3.5 percent; and in mixed conifers, 5 percent.

II. EXTERNAL EVIDENCES

To the lumberman or wood-chopper the evidence of the presence of red rot in a standing tree in the forest is unmistakable. If a glance at its general appearance does not tell him, he sounds the tree with his axe to see if it is worth felling. To the untrained person, however, considerable observation is necessary to judge with any degree of accuracy whether a tree is or is not diseased. Of course the discovery of a fruiting body (Plate III) is a sure indication, but aside from this evidence one can judge only from general appearance. Perhaps the most reliable indication, at least in the pine and spruce, is the abnormal exudation of pitch or resin from old knot-holes, or, if the disease has progressed far enough, from other points on the bark. This pitch drops down the sides of the tree and is very noticeable, as is shown in Plate II, upper left hand corner. If the fungus has invaded the trunk of the tree sufficiently to affect its health seriously, a general paleness of the bark and even of the foliage ensues. These evidences are not confined to any particular part of the trunk. The very first stages of the disease are betrayed by this pitch exudate. Suspected trees manifesting these early evidences of the malady were cut, which, upon internal examination, revealed only the red color of the heartwood, which is the result of the first structural change brought about by the fungus. Later in the progress of the disease all the external evidences become intensified so that advanced stages are detected more easily.

III. SPECIES AND CONDITION OF TYPES ATTACKED

Susceptibility of species. Red rot is found commonly in the five soft wood species: pine, spruce, hemlock, balsam and tamarack. Von Schrenk (2) states that "of the five trees the tamarack seems to be the most readily attacked, the spruces come next and the balsam fir last." Although tamarack is not as plentiful in Vermont as the other species, the writer's observations tend to confirm Von Schrenk's statement as to its susceptibility. In regard to other species, however, the writer's study of his data leads him to conclude that, in Vermont at least, white pine is second in susceptibility, while spruce, hemlock and balsam are susceptible to invasion in about the same degree. It was noted that spruce in mixed stands appeared more prone to attack than when growing in a pure spruce stand. This is not easy to explain, unless it may be due possibly to better self-pruning and to more healthy and favorable silvicultural conditions.

Pure white pine stands showed greater amounts of red rot than did any other type. Where the disease was present at all in the white pine, it seemed to be distributed much more uniformly than in the mixed stands.

Silvicultural conditions. Certain silvicultural conditions appeared to favor the presence and spread of the disease. It was predominant especially in tracts which were in need of thinning. A notable case of this sort was found in Orange County where the trees ranged from 6 to 14 inches in diameter at breast height and were growing so closely together that the wind had broken many branches. The heavy mass of crowns did not allow the entrance of sunlight, which is an important factor in the healthy growth of a forest.

Topography. So far as could be determined, the effect of topography upon the presence of the fungus seems very slight. The reports of lumbermen on this point were variable and evidently were governed by local conditions. Comparison of the opinions of lumbermen in different localities, strengthened by the writer's observations in the woods, leads to the conclusion that red rot lumber is as common on high rocky land as in the swamps and lowlands, with the exception of tamarack which, of course, occurs only in lowlands.

Wind. It is believed that the wind is a more important factor than topography. Areas exposed to heavy winds show more red rot decay than do sheltered stands. This condition might be explained by the fact that the damage done by the wind in breaking branches leaves open places or branch wounds where the fungus may enter the tree. The wind also aids in carrying spores from one tree to another.

Age. Previous writers have ascribed much importance to the supposed fact that only the oldest trees in the stand are affected. While this may be true in some sections, many specimens of trees not more than 25 or 30 years old were found by the writer to be infected. Von Schrenk's statement that the fungus attacks living trees only after they have reached the age at which they form heart-wood, probably is a more correct conception of the matter.

IV. DISTRIBUTION

Numerous German references report the occurrence of this fungus in all parts of that country where any considerable stands of coniferous trees are found. Möller (5) says "It is present wherever the conifers grow in any abundance and the damage caused by it reaches into the millions of dollars annually." Hartig (1) states that it is very abundant in the pine woods of North Germany and occurs also, but less frequently, in the spruce woods of South Germany. That it affects the conifers in other eastern countries is evidenced by the report of Khan (6) on its occurrence in India in 1904.

Von Schrenk (2) has reported in a general way on its occurrence in Maine and other New England states on white pine, red spruce, white spruce, hemlock and tamarack. The parasite attacks living trees after they have reached the age at which they form heart-wood, and honeycombs the wood in such a way that it appears to be filled with small holes, many of which seem to have a slimy white lining.

The writer has tried to secure information which would afford accurate data concerning its occurrence in Vermont, by the collection of statistics from different parts of the State. The percentages of disease in spruce and mixed stands appear to be fairly uniform in all places where data were obtained. With the exception of a few local situations, either badly infected or entirely free from disease, one may expect to find in most cuttings losses varying from 3 to 5 percent.

The presence of the disease, however, was not as uniform in pine trees as in the others mentioned. Many small tracts, especially isolated ones, were found where no disease was apparent. On the other hand other places were found where many trees were affected and the loss was very large.

With the exception of the Passumpsic valley, which appears to be excellent pine land, and where very little red rot was found, the distribution of the disease is irregular. Along the shore of Lake Champlain, tracts less than ten miles apart were located where both extremes of conditions were found. The Connecticut valley shows a similar condition.

It is the writer's opinion that the best pine lands show the greatest freedom from disease because the more rapid and uniform growth results in better self-pruning and healthier general conditions.

V. THE FUNGUS

Name. The fungus causing the red rot of conifers is one of the Basidiomycetes, *Trametes Pini.* It is a parasite of growing coniferous trees and assumes the characters of a saprophyte, (that is to say, a fungus living upon a dead plant or animal) to a greater or less extent upon the death of the tree, so long as the moisture and food contents of the host remain favorable to its development. The question of its adaptability to a saprophytic mode of life is one of much economic importance from the point of view of its ability to continue the formation of fruiting bodies on fallen trees and thus greatly to increase the spread of the disease.

Growth of mycelium. Von Schrenk (2) states that destruction of the wood, at least, ceases upon the fall of the tree, but that whether the fruiting bodies on fallen trees do or do not function to any great extent remains an open question. That the growth of the mycelium (the thread-like tubes which penetrate the wood and nourish the fungus, tubes which in their function are analogous in a way to the roots of higher plants) in fallen trees is dependent almost entirely upon moisture conditions, was proved conclusively by the writer by taking uniform slabs of diseased pine, placing them in various conditions of moisture and watching the progress of the growth of the mycelium and the destruction of the wood. Slabs placed under cover where conditions are such as are found ordinarily where lumber is seasoned, showed no further growth of the fungus. The wood dried out and its pithy appearance assumed a more open character. On the other hand, slabs of the diseased wood left in contact with the ground, or near moisture, showed abundant growth of the mycelium, which extended even to the surface of the wood. Whether infected wood left in such conditions ultimately would or would not form functioning fruiting bodies, is undetermined. However, it is believed that trees which fall in the woods as a result of permeation by the fungus do not fall ordinarily under such conditions as tend to favor the continued growth of the mycelium. The trunk of the tree is more likely to be attacked by fungi such as *Lenzites sepiaria* and other saprophytes that can live in a drier situation.

Method of attack. Any tree wound which opens up a way to exposed heart-wood enables the red rot fungus to germinate and the mycelium to penetrate the wood. Once the mycelia have gained entrance, they spread rapidly, both up and down the trunk, along the tracheids (i. e. wood cells used simply as water carriers) longitudinally, and more slowly across radially.

Resistance. Apparently the only resistance offered by the tree takes the form of a free exudation of pitch. In the younger trees this discharge is sufficiently large to hinder the progress of the mycelium while the lessened amount of pitch which is exuded by the older trees accounts for the increased destruction.

It is stated by Von Schrenk (2) that the mycelium of *Trametes Pini* flourishes in both the heart-wood and sap-wood of spruce, hemlock, fir and larch, while in pine it grows only in the heart-wood. That the latter is not always true is shown in Plate I of a cross section of an eight-inch pine, in which it will be noticed that the destruction has continued irregularly into the sap-wood. This specimen was taken from a standing tree upon which a fruiting body was found.

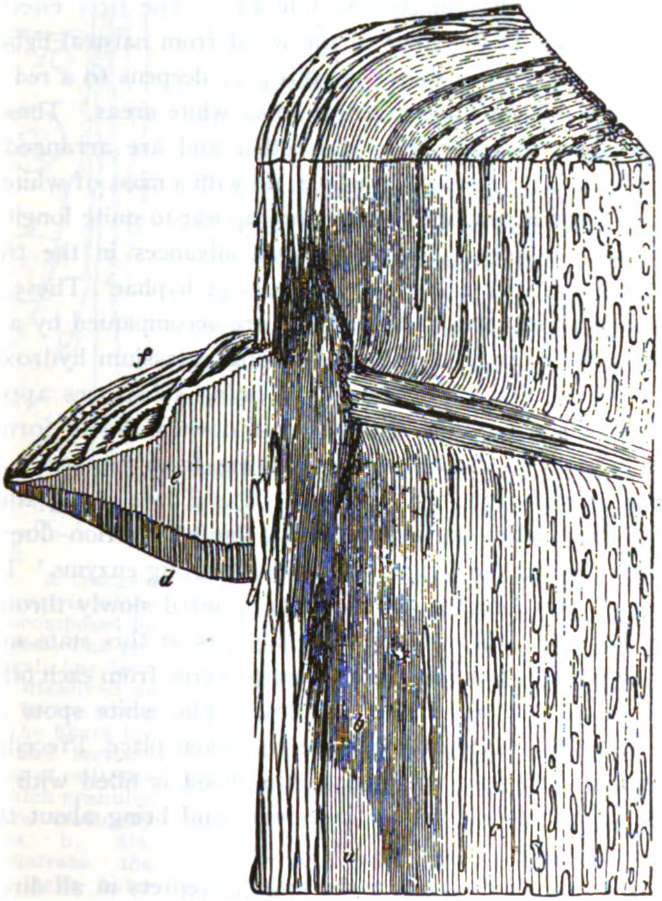

Figure 1. Part of stem of a pine bearing sporophore of *Trametis Pini* (one half natural size) (After Hartig).

Hartig (1) says the fungus cannot enter through old branches naturally pruned. This point was investigated and it was found that the tree forms a natural protection for itself. When the branch dies the free exudation of pitch causes that part which lies adjacent to the cambium, (the growing tissue just inside the bark), as well as that inside the tree to become hardened and impenetrable. This condition is shown clearly in Figure 1, which is a longitudinal section of a diseased pine, cut squarely through the center of the knot. It will be noticed that the fungous growth is present in the vicinity but does not penetrate this resinous wood of the old branch.

Morphological characters; wood dissolution. The visible effects of the growth of the fungus in the wood are described by Von Schrenk (2) for spruce in part as follows: "The first effect to be noticed is a change in the color of the wood from natural light straw color to a purplish gray. Very soon this gray deepens to a red brown. Black lines precede the appearance of small white areas. These areas usually are some distance from each other and are arranged longitudinally (Plate II). Some of the holes fill with a mass of white fibers. As the holes grow in number and size they appear to unite longitudinally rather than radially. As the disease advances in the tree, the destroyed cells fill with a dark brown mass of hyphae[1]. These hyphal plugs occur in nearly every tracheid and are accompanied by a brown incrustation which dissolves in part in dilute potassium hydroxid and entirely in warm nitric acid. These incrusting substances apparently were decomposition products and were laid down in liquid form.

"The changes in the cell walls resulting from the attack of the mycelium are fully described by Hartig (1). There is a gradual extraction of those elements which give a lignin[2] reaction due to the probable secretion by the fungus of lignin-dissolving enzyms.[3] This begins in the tertiary lamella and proceeds outward slowly through the secondary lamellae. The primary lamella splits at this state and dissolves, leaving the individual tracheids entirely free from each other and composed approximately of pure cellulose. The white spots are the points at which the change to cellulose has taken place. Preceding the change of the wood fiber to cellulose, the wood is filled with masses of hyphae which become masses in centers and bring about the dissolution of the wood.

"The hyphae grow out from the original centers in all directions, proceeding faster up or down the stem parallel to the tracheids than they do across them. It is the opinion of the writer that the decomposition products cause the destruction of the wood to stop at this point. In the newly invaded trunks the mycelium is colorless. The hyphae are somewhat thick walled and have numerous short branches which penetrate the walls in all directions."

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[1] The term "hyphae" as used here, is synonymous with mycelia.
[2] The woody substance of the cell wall.
[3] An enzym is a ferment possessing the power to decompose organic compounds.

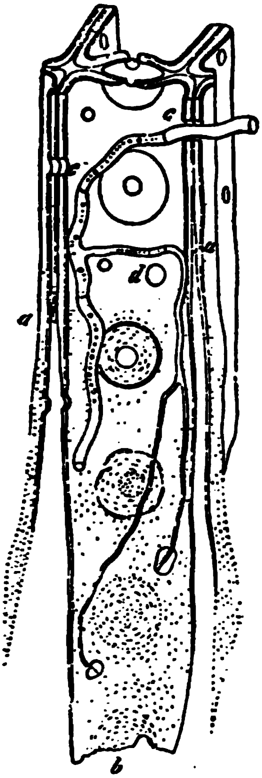

Figure 2. A tracheid of *Pinis sylvestris* which has been decomposed by *Trametes Pini*. The primary cell-wall has been completely dissolved as far as aa. In the lower portion of the figure the secondary and tertiary walls consist of cellulose alone, in which granules of lime are distinctly recognizable, b; filaments penetrate the walls and leave holes behind, d. e. (After Hartig).

Figure 2, copied from Hartig, shows more clearly than can be explained the appearance of the mycelium in the tracheids and the gradual solution of the lignin brought about by the enzym of the fungus.

VI. CULTURAL STUDIES

Specimens of diseased wood were secured from several sections of the State, though mostly from forests near Burlington, in August, 1912, the trees being in various stages of decay. These specimens were examined microscopically and the fungus was grown on lima bean agar (Clinton's formula) and a synthetic agar composed of peptone and the necessary salts, which was strongly acid in its reaction.

Inoculation methods. Some samples for inoculation were taken from standing trees on which fruiting bodies had developed, others from logs or sawed lumber in lumber yards, and in two cases successful cultures were made from particles of wood taken from a knot-hole in a suspected pine upon which no fruiting body could be found. The mycelia obtained from all these sources showed noticeable uniformity in their growth or media. Particles of fruiting bodies also were used for inoculations and, in comparison with each other and the cultures made directly from wood, gave equally uniform results.

Most of the inoculations were made directly from the specimens of wood. By carefully handling the specimens with sterile forceps and cutting away the external portions of the wood with a sterile knife, small particles of the diseased wood fiber were obtained, which, when introduced upon the surface of the tubed media, gave about 90 percent of pure cultures.

Mycelial growth. At first the mycelium made slow growth, from ten days to two weeks being required before visible growth could be detected in the tubes. Plate IV shows a photograph of a six-weeks-old culture on lima bean agar. During the first stages of the growth the hyphae, (that is to say, the filaments of the fungus), were pure white in color. They spread over the entire upper surface of the media, forming a mat about one-sixteenth of an inch in thickness. In no case did they penetrate the media to any extent.

Inoculations were made upon media in deep petri-dishes, about 2.5 inches deep and 3.5 inches in diameter, in order to promote a longer period of mycelial growth before the media began to dry. The growth in the petri-dishes was not essentially different from that in the tubes.

In all cases the mycelium retained its white color for a period of from six to eight weeks, then slowly turned to a brown which grew steadily darker for about eight weeks, after which time there seemed to be little increase in amount of mycelium and no change in color. The brown color exhibited so uniformly by the culture apparently is due to a sort of incrustation which is laid down about the mass of mycelium. The fact that this incrustation is soluble in part in potassium hydroxid and entirely in warm nitric acid indicates, as Von Schrenk (2) has stated, that it is due to the presence of decomposition products. This coloring matter diffused through and stained brown the lima bean agar after two months. The growths on the two kinds of media differed only in minor particulars.

Sterile wood cultures. In order more closely to follow the fungus in its attack upon wood, cultures were made in the following manner: Small blocks were sawed from each of seven different kinds of healthy wood, spruce, pine, hemlock, tamarack, balsam, birch and oak. These blocks were taken from the trunks or branches and sawed in such a manner that both heart-wood and sap-wood were present in each block. They then were put into an ordinary test tube, in the bottom of which had been placed previously a small ball of water-soaked cotton. The tubes then were plugged and sterilized. Inoculation was accomplished by introducing small particles of mycelium from previous media cultures. Growth in the dark and at room temperature started on the wood almost immediately and spread irregularly over the entire surface of the block. Eight inoculations, besides a check, were made on each kind of wood and in 95 percent of the tubes the cultures appeared pure. The fungus apparently showed no preference for the sap-wood.

Growth on different species. Comparison of the amount of hyphae in the tubes showed that the susceptibility of the wood seemed to range in order as follows: Tamarack, pine, hemlock, spruce, balsam. This order of susceptibility is the same practically as that noted by Von Schrenk (2) in New England forests.

The inoculations made on oak and birch were successful, the fungus growing luxuriously; but the damage to the wood was done more slowly and its extent relatively was very limited. The attack of the fungus on the hard woods should be studied more thoroughly. The preliminary sterilization, of course, may have rendered them soft and also may have brought about chemical changes which rendered them more readily open to attack than when in their natural state.

The brown incrustation occurred fully four weeks later in the case of all eight cultures of the tamarack and balsam than in the cultures on pine, spruce, and hemlock inoculated at the same time. Microscopical examination revealed no essential difference in the fungus as cultivated on the different woods, except that the hyphae cells possibly were a little larger in diameter on the tamarack and smaller on the hard woods.

Influence of moisture. The growth of the fungus is profoundly affected by the presence or absence of water in the tubes. Without exception whenever moisture was lacking to any great extent, the growth of the fungus was affected directly. If water was omitted at the time of inoculation, the culture failed to develop. If the fungus grew luxuriantly in the presence of moisture it ceased its growth immediately and dried up if the water supply was withdrawn. Tubes in which this drying out process had taken place once, but slowly reestablished growth upon the addition of water.

Spores. The cultures were examined microscopically at various stages for spores. The last of these examinations was made in May, 1913, and, even on cultures which had been growing since September, 1912, no trace of such reproduction could be found. The marked uniformity of the general characters of the mycelium, noticed in all the slides prepared from the different cultures, indicated that the same fungus had been isolated in all cases. The growth of the fungus on the sterilized wood cultures produced the same appearance as that taken from a diseased tree in the forest. Blocks of wood are shown in Plate IV on which the fungus had flourished for a period of six months but from which the mycelium was scraped from the wood to show more clearly the presence of the white-lined pockets which are so characteristic of the disease.

VII. EFFECT OF THE FUNGUS ON THE WOOD

The change from the natural color of the wood to a red brown has been responsible for the name of "red rot" lumber, by which woodsmen and lumbermen designate the diseased wood.

Breaking and crushing strength tests. In order to show the extent to which the changes wrought by the fungus as outlined on pages 7 to 10 take place, and to afford a comparison of diseased and healthy wood from the standpoint of the use of lumber for manufacturing purposes, tests of breaking and crushing strengths were carried out as follows: A complete section of a diseased pine log about 12 inches long was taken from a standing tree in Bradford. This tree was about eight inches in diameter and about 35 feet high. A fruiting body was found at a knot-hole four and one-half feet from the ground. A cross sectional photograph (Plate I) indicates the extent to which the fungus had penetrated the wood. This 12-inch section was seasoned in a boiler-room where it was subjected approximately to the heat employed in an ordinary kiln-drying process. The log then was sawed as economically as possible into sticks with an average measurement of 1.1 x 1.2 x 10 inches. These sticks were assorted then into three classes, according to the extent to which the fungus was present in each, as follows:

(1) Showing very little or no evidence of disease.
(2) Fungus growth on one or two sides.
(3) Thoroughly ramified by the fungus.

The weight of each stick and its volume by displacement of water were obtained. Breaking strengths were determined on sticks ten inches long and crushing strengths were determined on five-inch lengths.[1] Four sets of tests were conducted for each class. A summation of results follows:

SUMMARY OF TESTS FOR THE THREE CLASSES

Class	Volume c.c.	Weight grams	Diameter inches	Pounds to break	Pounds to crush
Free from disease	240	89	1.1 x 1.2 x 10	610	6620
Partial infestation	247	78	1.1 x 1.2 x 10	498	3910
Complete infestation	248	67	1.1 x 1.2 x 10	337	2440

This table is self explanatory. It shows plainly the relative decrease in weight and in breaking and crushing strengths proportional to the extent to which the fungus had penetrated.

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[1] The strength tests were carried out in the College of Engineering under the direction of J. O. Draffin of the Class of 1913.

Clearly the fungus is capable of destroying the wood and makes it unfit for manufacturing purposes. The advisability of cutting and marketing trees affected by the disease as soon as the presence of the fungus is noted, is evident. In this way only can the timber be used at all. It should be noted that the strength of the sticks cut from disease-free wood corresponds closely to that of standard seasoned pine. This tree, as a whole, however, was affected so seriously with disease that at least 50 percent of it would have fallen into a $10 grade, and 25 percent of it was utterly useless.

VIII. METHOD BY WHICH THE FUNGUS SPREADS THROUGH A FOREST

Root infection. According to Khan (6) an examination of various specimens of the roots of coniferous trees in an East Indian forest infected with *Trametes Pini* showed that there is a strong possibility that the disease may spread by the passing of the mycelium from the roots of diseased to those of healthy trees. Even more striking is Runnebaum's (4) statement based on the inspection of 70 infected trees, to the effect that 50 of them had been infected from the roots. A careful examination of the roots and trunks of these 50 trees, on the side on which the fruiting bodies occurred, showed mycelium up to a point only half a meter higher than the level of the ground. The infection in the other 20 trees evidently had occurred in a branch wound, because the rot was confined to the parts above ground. While this channel of infection may be open to some cases, the chances of the fungus penetrating the cambium and sap-wood of an uninjured root seem rather slight. In any case the fungus can be spread thus but slowly. The writer is of the opinion that root infection does not take place to any great extent in this locality, certainly very few of the specimens seen in Vermont were diseased below the ground. It may be that the fungus has been confused with its closely allied form, *Trametes radiciperda,* which produces much the same condition of decay in the wood but is spread solely by underground methods, its fruiting bodies forming below the surface. Tubeuf (3) has made clear the distinction between *Trametes Pini* and *Trametes radiciperda,* although the two species produce much the same condition in the wood.

Fruiting bodies or sporophores. The fungus follows in general the habits of other wood fungi and spreads through a forest mainly by the production of spores in a fruiting body, or sporophore. That these sporophores are very plentiful on the diseased trees in German fore is indicated by the constant reference made to their occurrence by German writers. Von Schrenk (2) speaks of them as being "extremely common on all (New England) affected trees." Specimens have been collected from forests in Maine, New Hampshire, Vermont, New York, Ontario, Quebec and New Brunswick. However, the writer did not find these fruiting bodies as common, at least in Vermont, as they have been represented to be. No trace could be found on a large proportion of the infected trees, the only external sign of the disease being an abnormal exudation of pitch from knot-holes and a general pale and unhealthy condition of the foliage. However, the sporophores were found occasionally on every diseased tract.

The sporophore of *Trametes Pini* is easily distinguished from allied forms by the light red-brown color of the hymenial or fruit-bearing surface and by the regular small round pores. The pores on the specimens obtained in Vermont seem smaller than those occurring on specimens from other sections. The form of the pileus or cap varies with the species of the host plant. Hartig (1) ascribes this difference to the various amounts of resin contained in the trees of the several species. The sporophore on the pine appears characteristically in the form of a large bracket, situated on the surface of the tree where an old branch stub has broken off. Plate III shows this characteristic appearance. An exudation of pitch almost always accompanies the presence of the fruiting body. Plate III shows two specimens of fruiting bodies or sporophores collected, respectively, at Bradford and Burlington. In the case of the spruce, tamarack and fir, these characters do not hold. The form of the sporophore varies from that of an incrustation to that of a bracket, and it does not confine its location to the nodes but may develop at any point.

These sporophores give rise to the spores which are carried about by the wind until they find a suitable place for germination. Where old branches have been broken off, exposing the heart-wood before complete protection to the wound has been effected by the resinous deposit in the branch stub, the spore finds the most favorable conditions for entrance and germination. Its progress in the heart-wood is rapid, but when it reaches the resinous sap-wood its advance is slower. About this time the sporophores begin to form. Where the dead branches have been broken off close to the trunk, the hyphae grow out from the stub and form a cushion. Von Schrenk (2) has explained carefully in detail the progress of the growth of the sporophore on pine, spruce and tamarack. The cushion formed on the branch stub is very small at first and has the appearance of being covered with velvet. The radial growth of the hyphae is rapid and a sheet is formed which adjusts itself to the shape of the stub. At the edges this sheet projects from the bark and forms an irregular shelf, the top of which after a time becomes brown and hairy and ultimately develops into a bracket formation. The growth seems to take place most rapidly through the latter part of the summer and the early fall. The hyphae at the edge of the sheet extend their area, while those forming the walls of the pores grow vertically downward. It is not known to what age one of these sporophores may attain.

Most writers call attention to the fact that fruiting bodies are common only on the larger and older trees. While this is true to a certain degree, the production of sporophores by no means is confined to such trees. The writer found that they were as common on diseased trees less than seven inches in diameter as they were on larger and older trees. One good specimen was found on a pine about six inches in diameter and only about 30 years old. The entire surrounding stand in this case was only from 45 to 50 years old and fully as large a percentage of diseased trees was detected here as in any stand examined.

These fruiting organs exist on both standing and fallen trees. Von Schrenk says: "They were found on trees which had been cut down four years before and new ones were constantly appearing." In view of the fact that the mycelium practically ceases growth as soon as the wood is placed in a position where desiccation will take place, it would seem that such sporophores could not be kept in a condition to function for any length of time after the fall of the tree, unless the tree fell in a position to cause the excessive absorption of moisture. However, it is this faculty of fruiting to a greater or less extent on dead trees which must enable this fungus to accomplish its rapid spread.

IX. PREVENTIVE MEASURES

The discovery of this disease and of its method of spread in Germany immediately led to search for some means by which its ravages could be controlled. Most students of this malady as it occurs in Europe have suggested the following procedure:

1. *Prevention of branch breaking.* Laws have been enacted to prevent wood gatherers from breaking off branches which leave an open wound in the heart-wood, thus encouraging the entrance of the fungus. These wood gatherers damage forests which lie near cities and villages. They are supposed to take only the dry dead branch

but in so doing often remove branches which still are partly green and in which the protective layer of resinous wood has not formed.

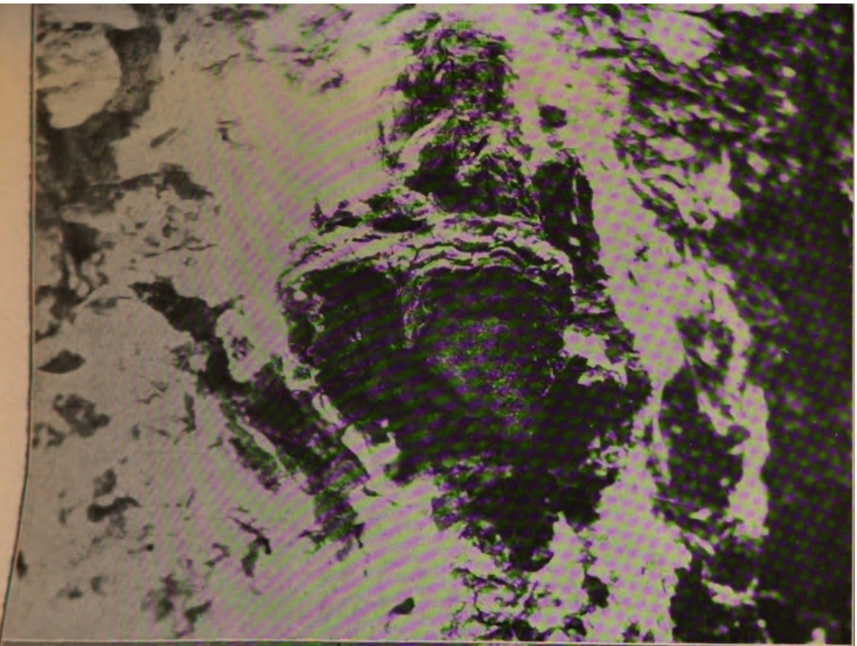
2. *Removal of fruiting bodies.* If fruiting bodies are removed and destroyed and a disinfectant is applied to their former sites on the trees much good will be accomplished. This may be done according to Möller (5) by a crew of two or three men equipped with ladders with instruments for hewing out the sporophores and with some form of disinfectant to apply to the spots where the fruiting bodies were located. Caterpillar tar (Raupenleim) is the disinfectant commonly used in this work. Its application in this manner is known to have prevented the formation of new fruiting bodies in at least 80 percent of the cases where it was used. Kienitz (8) states that it costs about 10 cents an acre to do this work.

3. *The cleaning out of infected trees.* Infected trees can be recovered thoroughly only by a careful survey of the tracts by a man who is trained in detecting the disease. The complete removal of the whole tree is necessary because of the chances of further infection, either from the mycelium or from fruiting bodies on the fallen trees. This operation should not be expensive, as enough of the lumber cut would be worth saving to pay for the cutting. This cutting could be made best in the form of a thinning. Hollrung (7) advises a complete inspection and cleaning of an infected forest every five years in order to maintain complete control of the disease.

Obviously all these methods are radical and are applicable in their entirety only where intensive forestry can be practiced. The problem of prevention in this country assumes a different aspect because lumber prices do not permit as intensive methods as obtain in Europe and because the sporophores apparently do not grow as abundantly, in the Northern states at least, as they do in Germany.

In view of the fact that evidence points toward the probability that fruiting bodies may form and function on dead trees, it appears that the first procedure should be to remove carefully all dead and diseased wood so that it will not spread the disease. Then, secondly, overthick plantations should be thinned.

The writer noted a significant fact in his study of Vermont forest conditions in their relation to red rot, namely, that the disease was much more prevalent in stands in need of thinning and of an improvement of silvicultural conditions than in well-handled stands. Proper thinnings should be made, if possible, in rotation. Thinnings thus



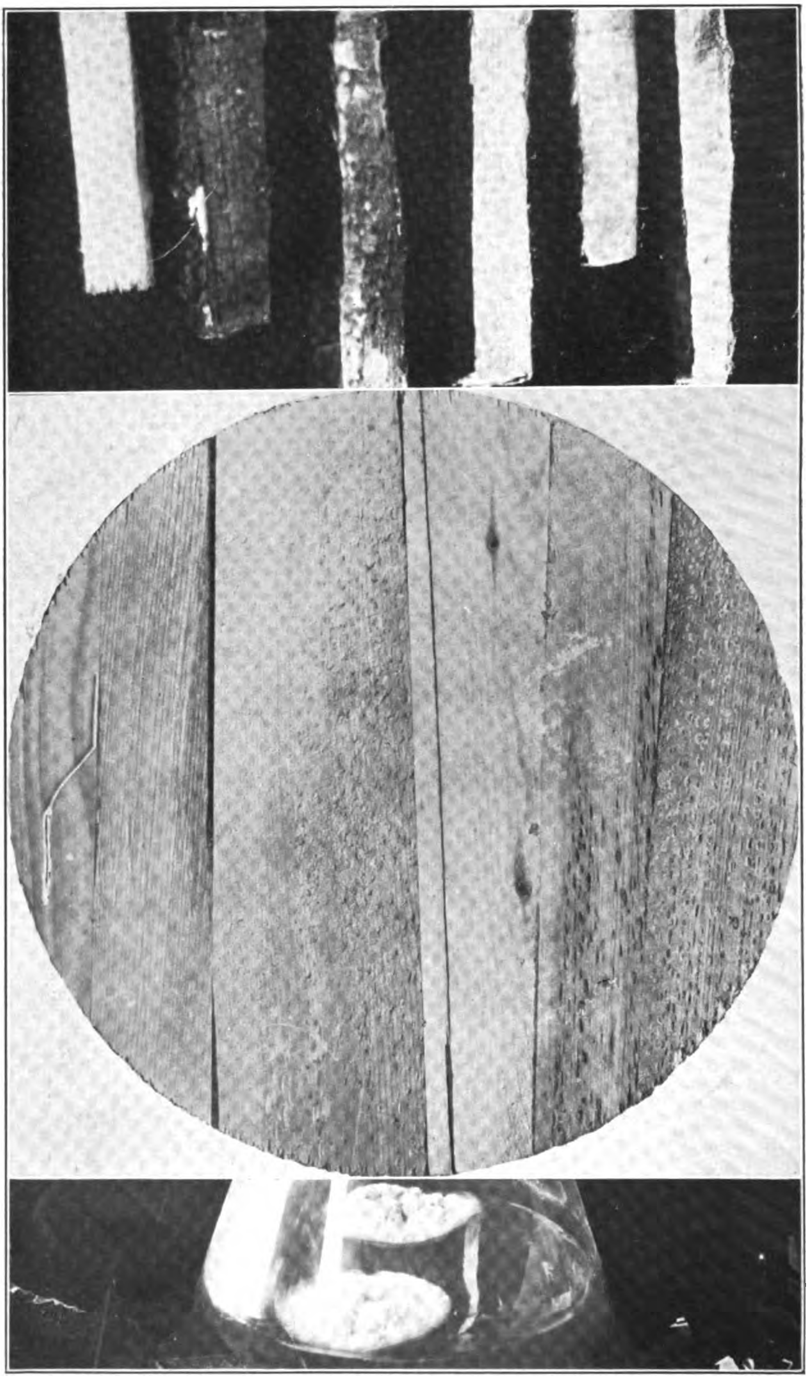


Plate IV. Wood chips upon which *Trametes Pini* had flourished for six months. Mycelium is scraped from outside to give clearer view. From left to right: check, pine, tamarack, hemlock, spruce, balsam (upper). Butter tub cover; showing how infected wood is utilized (middle). *Trametes Pini* growing in cultures (lower).

periodically made at intervals not more than 20 years apart, should provide easily for the removal of all diseased trees. In the University forest at Burlington, where such thinnings have been carried out, a much better distribution of the trees has been effected.

The present method employed in many forests of cutting to a diameter limit, is inadvisable, because it leaves trees which may be diseased, or which may spread the disease, or trees which on the whole are undesirable from the point of view of reproduction or future lumber production. Experienced markers should be employed who understand the importance of such matters and who would be faithful in attending to the general betterment of silvicultural conditions.

Some lumbermen who have become interested in forestry have thought that they could secure reproduction of spruce by leaving trees diseased with red rot for seed purposes, thereby avoiding the financial loss incurred by leaving sound trees. Such procedure is dangerous because it tends to perpetuate the disease, not through the seed of the old trees, but by the fungus upon them.

It would be impracticable under existing American forestry conditions to attempt such operations as making a complete survey to remove and disinfect fruiting bodies, unless it were in some valuable grove where expense was not a factor.

X. USES OF DISEASED WOOD

During the writer's studies of the red rot situation in Vermont lumber yards and mills, certain interesting points were noted as to the methods employed in making use of the diseased wood, as well as to the extent to which the fungus could destroy the wood without totally impairing its value for manufacturing purposes.

Red rot lumber, as is indicated in previous pages, is considered worth about $10 per thousand. It is defined usually as "box-board grade." Some manufacturers are able to use it in such ways that they can afford to pay as much as $18 for it. Such lumber often is reserved by dealers for local trade. As a rule it does not pay to ship it.

The lumber graded as mentioned above, box-board grade, finds its principal use in the manufacture of boxes of all descriptions. It is not used alone but is mixed with a better grade in order to furnish a marketable product. It is used also in making pails, tubs, kegs, etc. Perhaps this is a more effective method of making use of this wood than that just cited, since much poorer lumber can be used by virtue of the fact that a filler can be employed on the most decayed places and then the whole covered with paint to make an apparently perfect product. The photograph of a butter tub cover in the rough (Plate IV) shows the grade of lumber that can be used and also shows the proportion which can be introduced and still permit the structure to hold together.

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Vermont Agricultural Experiment Station
BURLINGTON, VT.

CIRCULAR NUMBER 6

January, 1911

FOREST NURSERY STOCK FOR DISTRIBUTION IN THE SPRING OF 1911

FOREST SERVICE PUBLICATION NO. 5

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PART I

The popularity of the State nursery has far surpassed the hopes of its original promoters and it has already become one of the chief agents in the forestry education of the state.

The number of trees sold in 1909 was 195,500; in 1910, 376,700. So great has been the demand for nursery stock that it has not yet been possible to hold over a sufficient number of two year seedlings to produce three-year-olds, which is the age of stock most recommended; and orders for about 50,000 trees had to be refused in the spring of 1910.

KINDS OF TREES RECOMMENDED

There are various types of lands in Vermont which should be planted to forest trees, as they would be more profitable when producing timber than when handled in any other way.

White pine.—For most of this land the white pine is the most profitable tree that can be planted. While it thrives well on a dry sandy soil, it grows even better on a loam. After it is once started it will grow from one to two feet in height a year for forty to fifty years. It is perhaps unsafe to plant it at elevations exceeding 1800 feet in the southern or 1500 feet in the northern part of the State. Near these limits of elevation a southern exposure is safer than is one facing north.

Scotch pine.—There are in certain portions of the State, notably in the Passumpsic valley near Lyndonville and in Castleton, Rutland county, areas of shifting sands. One of the approved ways of checking such encroachings is to plant the areas with some forest tree. The Scotch pine is even better adapted for these extremely dry situations than is the white pine. Furthermore it makes a more rapid growth than does the latter, at least for the first thirty years. The height growth on fair soil is often three feet a year.

Norway spruce.[1]—For the abandoned pastures at high elevations and especially for the hill tops and mountain slopes from which spruce has been cleared, the planting of Norway spruce is recommended. Spruce should not be planted on sandy land.

Black or yellow locust makes a good tree for fence posts, railroad ties, etc., but should only be planted on good soil, since it is more apt to be attacked by the locust borer on sandy soils.

Seedling versus planting.—Inquiries are frequently received as to the advisability of sowing pine seed. Experiments in this country and abroad have demonstrated thoroughly that satisfactory results cannot be expected if seed is sown on unprepared land, but may sometimes be obtained by plowing furrows five or six feet apart and sowing the seed in these furrows at the rate of two pounds or more per acre. A better method yet is to plow and harrow the land and to sow it broadcast to buckwheat and to at least two pounds of pine seed. Either of these methods is nearly as expensive as is planting and is much less satisfactory. Furthermore, it is impracticable for most of the land where forest planting is desired.

PRICES OF NURSERY STOCK PER THOUSAND, SPRING 1911

White pine 2 year seedlings[2]	$3.10
White pine 3 year transplants[2]	5.00
Scotch pine 2 year seedlings	3.10
Scotch pine 3 year transplants	4.75
Scotch pine 4 year transplants	7.00
Black locust 1 year seedlings	2.00
Black locust 2 year seedlings	7.00

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[1] Unfortunately the small supply of this stock available for this year is already engaged.

[2] Seedlings are raised in the seed beds two years and are then transplanted. A year after this transplanting they are called three year transplants.

Transportation.—The prices given above are for stock packed at the nursery, ready for shipment. All transportation charges are borne by the purchaser. When sent in baskets a charge is made of $1 per basket (a basket holds about 5,000 two-year-old pines). If, however, these baskets are at once returned, express prepaid, with name of shipper affixed for identification, the charge will be deducted. An idea of the cost of transportation may be obtained from the following figures of last year's shipments.

40,000 3 year and 4 year transplants of white pine, weight 2 tons, express charges Burlington to Springfield, Vt., $27. Cost per thousand, 67 cents.

12,000 2 year seedlings of white pine, express charges New Haven, Conn., to Milton, Vt., $2.75. Cost per thousand, 23 cents.

15,000 4 year transplants of white pine, weight 1,500 pounds (100 pounds per 1,000 trees packed), express charges Burlington to Plainfield, $7.30. Cost per thousand, 48 cents.

35,000 3 year and 4 year transplants of pine and spruce, freight charges Burlington to Sharon, $13. Cost per thousand, 37 cents.

From the above it will be seen that the express charge on two year seedlings is less than half of that on three year transplants; also that the freight charges on transplants from Burlington to Sharon were 30 cents per thousand less than the express charges on similar stock from Burlington to Springfield, Vt., a distance of about fifty miles more.

In the future, unless otherwise directed by the purchaser, all orders of coniferous seedlings not over two years old, and orders of less than 10,000 three or four-year-olds, will be shipped by express. All orders of 10,000 or more three or four year coniferous transplants will be shipped by freight.

Limit of orders.—No order for less than 1,000 nor more than 20,000 of any one kind will be filled. These trees are sold for forestry purposes and are to be planted solely within the State.

Payments.—Bills will accompany shipments. ***Postage stamps will not be accepted in payment.***

DIRECTIONS FOR PLANTING

Time of planting.—The sooner the planting is done after the frost is out of the ground in the spring the better. Evergreens should not be transplanted late in the season, after they have begun to grow, unless it is late in the fall. In Vermont the best season is usually from April 15 to June 1.

Unpacking stock.—The seedlings should be planted as soon as possible after arrival. If they cannot be planted at once, they should be heeled in, near the site that is to be planted. A ditch, preferably under shade, may be dug, and, after the bundles are untied, the roots should be covered with earth in this ditch, shading artificially if necessary.

Puddling.—Just before planting a thick mud should be made, preferably with clay. A few hundred trees are taken from the box or ditch and their roots dipped in this mud. These are then placed in a basket or pail and their roots covered with wet moss or cloth.

Spacing.—Dense planting is desirable so that the trees will automatically prune their lower limbs. They will thus make a better height growth than if wide spaced. After the lower limbs are killed the trees should be thinned. Planting 6x6 feet gives 1200 trees per acre; 5x6 feet gives 1500 trees per acre.

Planting.—The mattock or grub hoe is the best planting tool. The sod is first scraped away, then the mattock blade buried and the handle twisted to the right, making a hole at the side of the blade. The seedling is then inserted before removing the blade, and, after removing the mattock, the soil is pressed with the foot firmly about the roots of the seedling, leaving it in an upright position. Care should be taken not to let the roots dry out. Five minutes' exposure is often enough to kill them.

Crew.—Four men can work to best advantage, three men with mattocks, each following a straight line across the field, these lines kept approximately 6 feet apart, while a fourth man or boy carries the trees in a basket or pail strapped over his shoulder, and passes them out to the other three. Such a crew can plant from 2000 to 4000 trees a day, according to the kind of land.

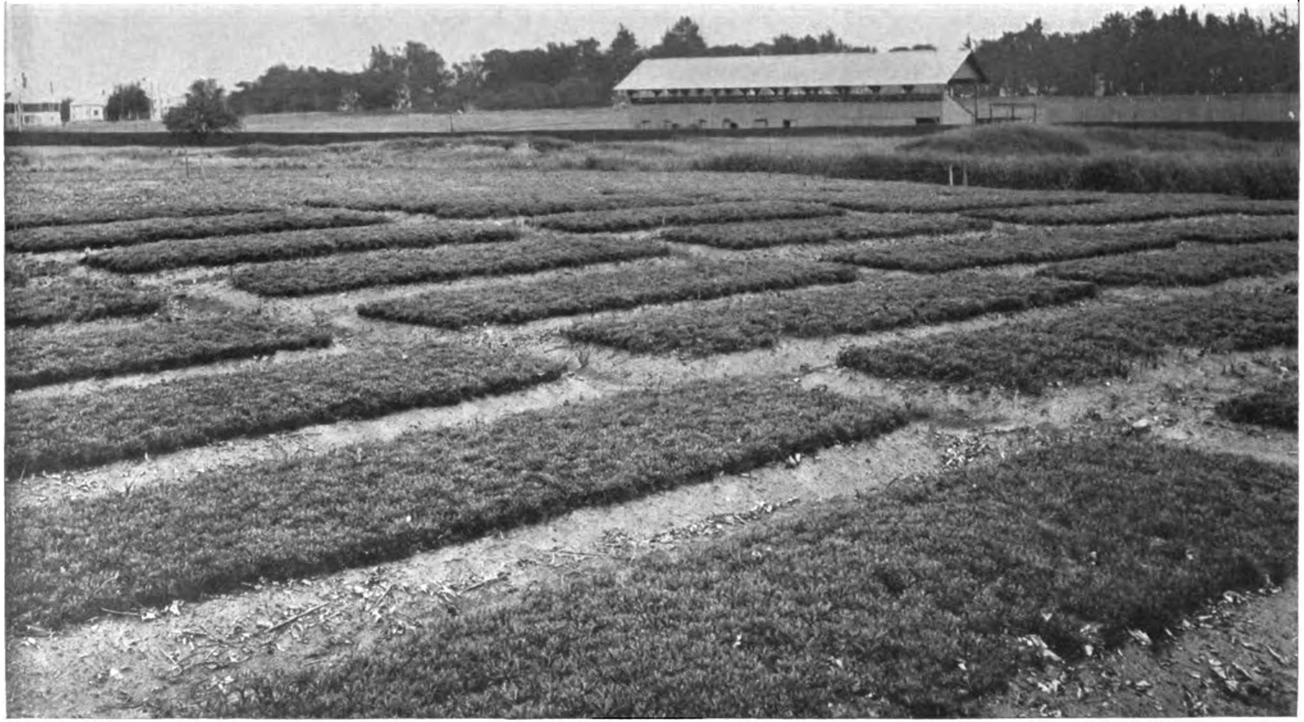

PLATE I
Seed beds of white pine in state nursery, Burlington.

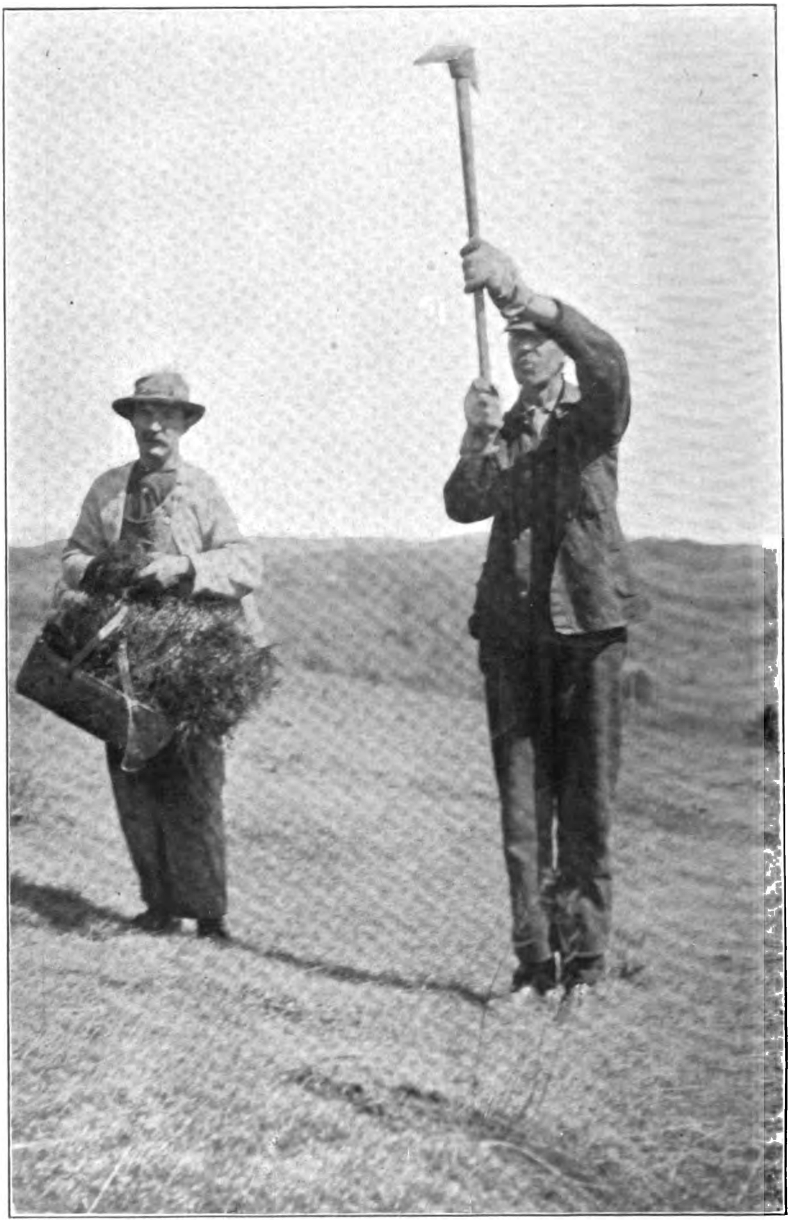

PLATE II
Method of planting seedlings with mattock.

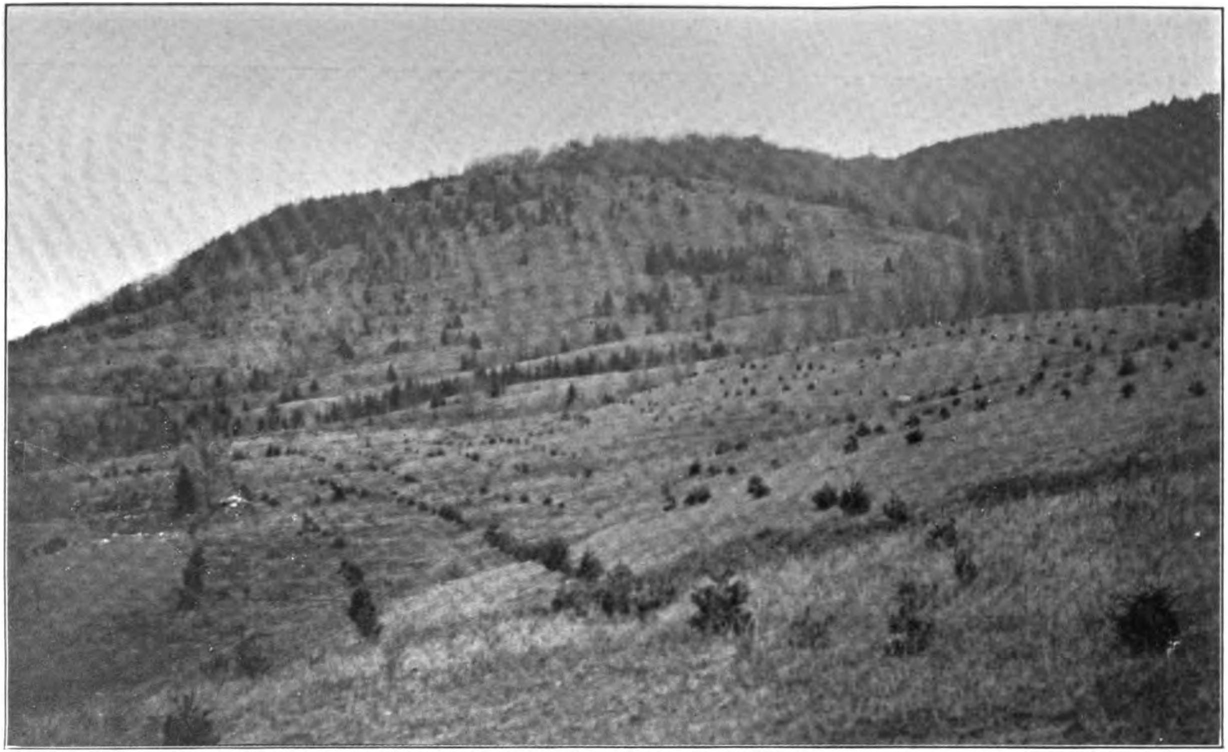

PLATE III
Pine plantation in Windham, Vermont. Five years after planting. Trees too far apart.

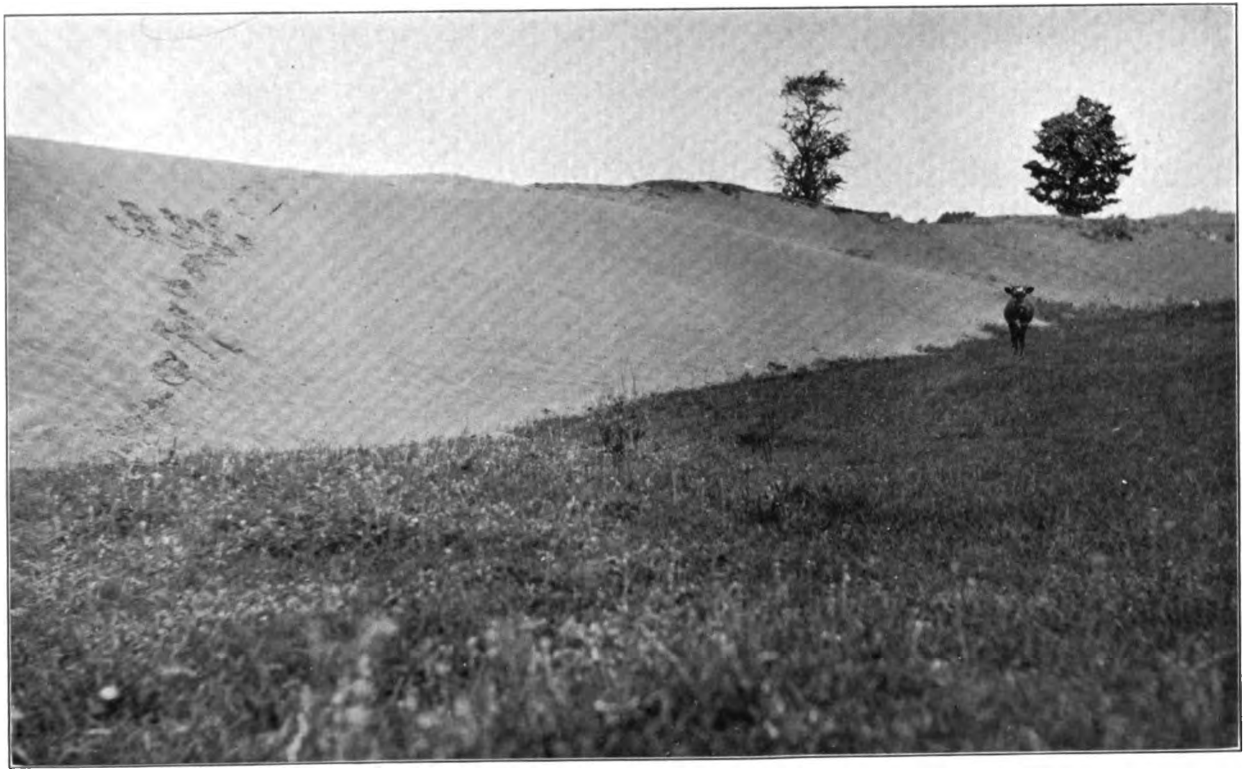

PLATE IV
A sand dune encroaching on farm lands in Castleton, Vt., which should be checked by forest planting.

COST OF PLANTING

On one day seven men planted on the state forest in Plainfield between 7,000 and 8,000 trees, i. e., an average of slightly over 1,000 trees per man a day.

In four days nine men planted on the state forest in Sharon 34,000 trees, i. e., an average of slightly less than 1,000 trees per man a day. These figures illustrate about the maximum rate of planting, for in both cases the land was free from rocks and brush and the men could work rapidly.

With labor at $1.50 per day the cost of planting is as follows:

	Per 1000	Per 1200	Per 1500
Planting 500 trees per day per man......	$3.00	$3.60	$4.50
" 600 " " " " "	2.55	3.06	3.82
" 700 " " " " "	2.10	2.52	3.15
" 800 " " " " "	1.87	2.24	2.80
" 900 " " " " "	1.65	1.98	2.48
" 1000 " " " " "	1.50	1.80	2.25

Considering the average railroad transportation charges as 30 cents per thousand and the cost of hauling from the railroad to the land 10 cents per thousand, the cost of planting various kinds of land is as follows:

Example 1. Using white pine 2 year seedlings at $3.10.

	6′ x 7′ = 1000 Trees per acre		6′ x 6′ = 1200 Trees per acre	
	Rough land	Easy land	Rough land	Easy land
Trees	$3.10	$3.10	$3.72	$3.72
Transportation	.40	.40	.48	.48
Planting	3.00	1.50	3.60	1.80
Total cost per acre	$6.50	$5.00	$7.80	$6.00

Example 2. Using white pine 3 year transplants at $5.00.

	6′ x 6′ = 1200 Trees per acre		5′ x 6′ = 1500 Trees per acre	
	Rough land	Easy land	Rough land	Easy land
Trees	$6.00	$6.00	$7.50	$7.50
Transportation	.48	.48	.60	.60
Planting	3.60	1.80	4.50	2.25
Total cost per acre........	$10.08	$8.28	$12.60	$10.35

Example 3. Using Scotch pine 4 year transplants at $7.00.

	6′ x 7′ = 1000 Trees per acre		5′ x 6′ = 1500 Trees per acre	
	Rough land	Easy land	Rough land	Easy land
Trees	$7.00	$7.00	$10.50	$10.50
Transportation	.40	.40	.60	.60
Planting	3.00	1.50	4.50	2.25
Total cost per acre	$10.40	$8.90	$15.60	$13.35

From the above examples it will be seen that the cost of planting an acre may vary from $5.00 for planting 1000 2 year trees on easy land to $15.60 for planting 1500 4 year transplants on brushy, rocky land.

Success of plantations.—The results of private planting and of that done on the two state forests indicate that with good weather conditions it is safe to expect the following results at the end of the first year:

White pine.	*Percentage alive at end of first growing season.*
Transplants, 3 or 4 years	85 to 98%
Seedlings, 2 years	75 to 90%
Woods grown stock	60 to 80%

Age of stock.—While the two year seedlings may thrive as well on light pasture where there is little grass growth as the three year transplants do on land covered with brush, the advantage on the same class of land is always with the transplants. Two year seedlings of spruce should never be planted in permanent site. One year locusts are from one to three feet high and are large enough for permanent planting.

PART II

PRIVATE NURSERIES

The raising of evergreen seedlings from seed is a business that requires considerable experience and a great deal of attention. For these reasons we believe that the state nursery can raise better stock and at a lower price than can most private parties. We do not, therefore, recommend the raising of nursery stock from seed.

There is, however, a phase of the nursery business which the private party can do successfully and advantageously to himself. This is the transplanting of seedlings into a private nursery. The chief advantage obtained by doing this is that the purchaser can thus be assured of a future supply of transplants and that they will be near at hand so that he can use them when he wishes.

Special offer.—The transplanting work has to be done in a short period of about six weeks just after the frost is out of the ground. During this same period the state nursery will be obliged to pack and ship about one-half million trees. If it succeeds in transplanting an equal number a large force of green men will be required, and it is difficult to organize such a force to work economically for such a short period. Crowding immediately on this comes the seed bed work which is now assuming very large proportions. For these reasons we are anxious to have the people of the State do some of this work of transplanting which can be done just as well, after a little practice, by any farmer. The mere work of counting out the stock costs considerable. The writer figured last spring that the average cost for taking up, counting, bundling, puddling, and packing trees of all ages was 55 cents per thousand. At least 10 cents of this charge is justly debited against the counting. In order to encourage private transplanting, the state nursery will furnish for this purpose two year white pine seedlings at $3 per thousand in quantities ranging from 10,000 to 20,000 on the understanding that the exact number is not guaranteed. The average weight per thousand of these seedlings will be ascertained and they will be counted by weight. In many cases the number will overrun; if it is less it will indicate that the trees are better developed than the average. In this way there will be a saving of $1 on every 10,000 trees.

Transplanting.—A good garden spot with a loam soil is the best place for transplanting. Unless the soil is already enriched, a fertilizer of manure or bone meal is desirable. The former should be plowed in, while the latter may be harrowed in or applied on top. When the soil is thoroughly fined the seedlings are put in in rows eight inches or a foot apart. The latter allows the use of a hand cultivator. The trees are spaced about two inches apart in the rows. The rows should be made straight with a string and a trench dug about six inches deep, perpendicular on the string edge, with a straight edge spade. The trees are held against the perpendicular wall of the trench and the earth is replaced and packed firmly against the roots. Care should be taken not to bury any of the needles.

During the past year we have used to facilitate this transplanting the Yale Planting Board. This is an ingenious device for holding forty or fifty trees in an upright position in the ditch while the earth is replaced. Two men are kept busy digging the ditch and replacing the earth, and two others fill the boards with trees. Two boards can thus be used to best advantage. The average cost of transplanting in the state nursery with the use of these boards, was $1.10 per thousand. The fertilizer, and labor in weeding and cultivating during the year amount to between 80 and 90 cents per thousand, making the difference in cost between $3.00 for 2 year seedlings and $5.00 for 3 year transplants.

Subsequent treatment.—The only care needed by these trees is to keep them well weeded and cultivated. No watering is necessary and no protection during the winter is necessary. They can be taken out and planted in the final site according to directions in the first part of this circular, the spring after transplanting, or they may be kept in the nursery two years—but not longer.

8

Vermont Agricultural Experiment Station

BURLINGTON, VT.

CIRCULAR No. 2

March, 1909

THE GYPSY AND BROWN TAIL MOTHS

WM. STUART, HORTICULTURIST

The Gypsy and Brown Tail moths have spread from Massachusetts to New Hampshire and other New England States. Immense sums of money have already been spent in an attempt to prevent further devastation. These facts quite naturally have caused alarm in Vermont, especially near the Massachusetts and New Hampshire borders; alarm manifested during the last year or two by the large numbers of insects sent to the Station, believed to be either the Gypsy or the Brown Tail moth. In no instance were the fears of the sender warranted. The writer has no personal knowledge of their invasion of Vermont. How long this statement may hold true cannot be foretold; but it is clear that the chance of infestation increases with their greater spread. *The earlier the State is informed of their arrival, the easier, the less costly and the more certain their extermination. Hence the residents of counties bordering on Massachusetts or New Hampshire territory should be especially observant of all unfamiliar caterpillars or moths.* When doubt exists they should be at once forwarded to the Station for identification. The Station will at once notify the Commissioner of Agriculture if as a matter of fact the specimen sent is of either species[1]. It is suggested that inasmuch as the present incumbent of that office is not an entomologist specimens be submitted to the Station rather than to him, in the interests of saving time and obviating the necessity of their transshipment. Place name and

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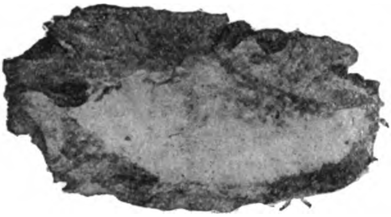
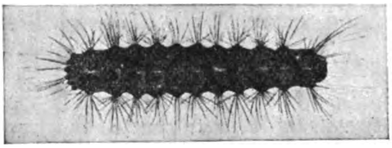
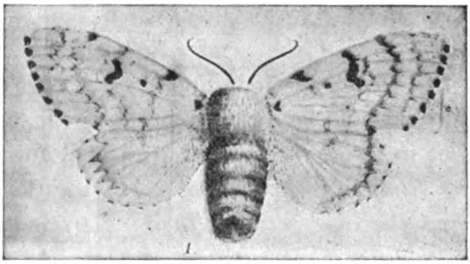
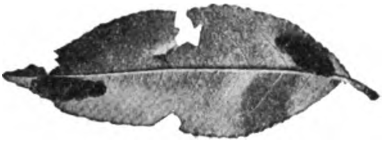
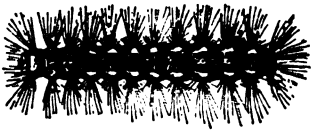
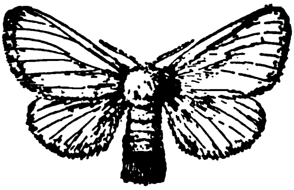
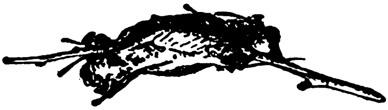
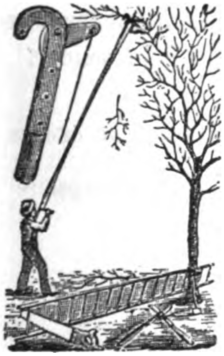
[1] Acts of 1908, No. 11, Sec. 8 (in part): Sec. 8. "Said commissioner may use such means as in his judgment are necessary to exterminate or prevent the introduction of the San Jose scale, the gypsy moth, the brown tail moth and any other threatening and unusual insect pest found to be injuring vegetable growth."

THE STAGES AND LIVES OF THE GYPSY MOTH

STAGES.	GYPSY MOTH.
EGG CLUSTER 	Usually on bark of tree; very rarely on leaf. Robust, 1¼ to 2 inches long. Light yellow or creamy. From August to May.
CATERPILLAR. Full grown 	Dark grayish or sooty. Double row of five pairs of blue, followed by six pairs of red spots along back.
MOTH. Female 	Wings spread 2¼ in. Dingy-white, lightly streaked and blotched with blackish. No brush of brown hairs at tip of abdomen. Does not fly, crawls.
WINTER PASSED	In egg stage—see above. Never as a caterpillar.
IRRITATION OF HUMAN SKIN	Not caused by any stage.
MOST EFFECTIVE MEANS OF CONTROL. Soak eggs with creosote in fall, winter, or spring.	

AND BROWN-TAIL MOTH CONTRASTED.

Brown-Tail Moth.	Stages.
Always on under side of leaf. Smaller and more slender. Dark or golden brown. July.	Egg Cluster. 
Bright tawny or orange. A conspicuous row of pure white spots or dashes along each side of body. Only two bright red spots on middle line at lower end of back.	Caterpillar. 
Wings spread 1½ inches..... Pure snow white. A conspicuous, sharply contrasted, thick tuft or patch of golden or brownish hairs at tip of abdomen. A swift, strong flyer, by night, and attracted to lights.	Moth, Female. 
As small caterpillars in a silken web or nest on tips of twigs, from which they crawl out in spring.	Winter Passed. 



IRRITATION.

Hairs from caterpillars, which are often transferred to cocoons and moths, cause an annoying and painful irritation of the skin.

Most Effective Means of Control.

Cut off and burn webs in winter.

postoffice address on packages. Specimens sent through the mail should be carefully enclosed in a package which is not easily broken or crushed, such as a wooden or tin box[1].

The food plants of these caterpillars in badly infested areas include the foliage of practically all deciduous trees. The Gypsy caterpillars usually attack forest and shade trees, while the Brown Tail prefers the foliage of the pear and apple.

The most marked difference in the life histories of these two insects, as noted in these illustrations[2], is shown in their winter habits. The Gypsy passes the winter in the egg, the Brown Tail as a young caterpillar. The distinct and characteristic markings of the full grown caterpillars and moths enable one to determine identities fairly well.

Methods of Distribution. The Brown Tail moth is best adapted by nature to spread over a wide area, for the female moth can fly to considerable distances, whereas the female Gypsy moth has very slight use of its wings. The usual methods whereby the latter are distributed are by the falling of the caterpillars onto passing vehicles (horse, automobile, trolley), they being thus borne considerable distances. The same means, of course, serve the Brown Tail as well.

Be on the watch for Gypsy and Brown Tail moths, especially in Windsor and Windham Counties, along the lower Connecticut River towns and the Massachusetts border.

Every New England State but Vermont now harbors these pests. The earlier they are combated, the shorter and more successful the battle.

Study the illustrations and descriptive matter and compare with specimens you may find.

Notify the Experiment Station, Burlington, Vt., if you think you have found either. Send specimens enclosed in a secure package, bearing name and address of sender.

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[1] Sending insects by mail improperly packed is an offense against postal laws.

[2] Furnished through the courtesy of the New Hampshire Experiment Station.

~~Percy F. Williams~~
M.A.C. 1905
N.D. Ingham

UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL
EXPERIMENT STATION
BURLINGTON, VT.

BULLETIN No. 76

MARCH, 1900

The Forest Caterpillar

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II. LIFE HISTORY—Pages 115-124
III. RAVAGES IN VERMONT—Pages 124-128
IV. THE COMBAT AGAINST THE FOREST CATERPILLAR—Pages 128-137
  1. NATURAL AIDS—Pages 128-131
  2. REMEDIAL MEASURES—Pages 131-137

BURLINGTON:
FREE PRESS ASSOCIATION, PRINTERS AND BINDERS.
1900.

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☞Address all communications, not to individual officers, but to the Agricultural Experiment Station, Burlington, Vt.

Director's office, chemical and horticultural laboratories are at the Experiment Station building, at the head of Main Street; botanical and entomological laboratories are at Williams Science Hall, University Place.

Experiment Farm and buildings are on the Williston road, adjoining the University grounds on the East.

BULLETIN 76: THE FOREST CATERPILLAR

(*Clisiocampa disstria* Hub.)

By G. H. Perkins

I. INTRODUCTION

This insect is closely allied to the apple tree tent-caterpillar, and has often been confused with it by those not familiar with different species of insects. This is not strange because both in the larval and mature states the two species are much alike. The name forest tent-caterpillar is that by which this species has been long and widely known, but it is objected to by some of our best entomologists on the ground that it is not appropriate since the caterpillar does not make a tent, but only a sort of mat which lies close to a large limb or to the trunk of an infested tree. While this name is, as has been stated, that which is most common, there are several others which have been more or less used at one time or another. Without entering into a discussion of the merits of any of these names, but simply for convenience the insect will be termed throughout this bulletin the forest caterpillar, for the reason that, as this bulletin is prepared not for the country at large but for the people of Vermont, it seems to the writer best to use the name by which the insect is most commonly known in this state.

The ravages of the forest caterpillar began to attract attention to some extent in this state in 1895. In 1896 they had become so extensive and wide spread that no little alarm was created lest the maple groves and shade trees of the state should be seriously injured. The continued abundance of the caterpillars and the very great damage which they have committed during 1898 and 1899 have shown that these fears were only too well grounded. In some places in the state the damage which was done in 1896 was as great as in any subsequent year, but as a whole the state has suffered more during the past two years than previously. Although I do not find any record of an attack so wide spread and destructive as has been that of the last three years, yet the forest caterpillar is not a new insect in Vermont. In a book published in 1791 I find an account of the presence in great numbers of a caterpillar which seems to be the same as our present pest. At different times since the beginning of the century there have been seasons in which this insect has committed more or less noticeable damage in Vermont, and, indeed, in nearly every state in the Union and in parts of Canada. Still, the recent ravages far exceed any that have taken place heretofore. Nor has Vermont suffered alone. In some parts of Maine, New Hampshire and Eastern Canada the devastation has been great, and Lowe[1] states of New York that he is "unable to find any records which indicate that it has ever before occurred in such great numbers over so wide an area within our borders." The pest appears to have been active over the entire state, but it was much more abundant in the southern and eastern counties than elsewhere, that is, in those portions of New York which are nearest Vermont.

Probably no species of insect has ever attracted greater notice in Vermont or caused more alarm or actually done as much mischief as this. It has been found in nearly all of our towns, though it has not done much harm in some. So far as I can learn it has not been as destructive in the northern part of the state as in the southern, while the middle counties seem on the whole to have suffered most.

In many places the caterpillars have not spread over the whole town, but, starting at a given point, they have moved on in a narrow band a few rods wide, all of the leaves of trees within this belt being destroyed, while the trees on either side were scarcely touched. Sometimes these belts were so narrow that only a portion of the trees of a single grove were injured. I do not intend to say that this is the usual habit of the caterpillar, but only that it is not infrequently the case.

On account of the injuries inflicted by the forest caterpillar in 1896 and 1897 a portion of Bulletin 60 (October 1897) was devoted to a consideration of its habits; but the prevalence of the insect since then and the numerous enquiries that have come to the station appear to warrant a more complete account both of the insect and of such methods as have been devised for its destruction.

At the outset I wish to call attention to the fact that not all the damage which our maples have suffered is caused by the forest caterpillar. In some groves great harm has been done by the large maple borer, *Plaginotus speciosus*, Say., and in other places, and these have been numerous, the fall canker worm, *Anisopteryx pometaria*, Harr., has done not a little of the leaf stripping which has been attributed to the forest caterpillar. The fall canker worm was very abundant in different parts of the state during the fall of 1899. Nevertheless, no other insect has at all equalled the forest caterpillar in destructiveness.

Perhaps no other insect is found in such immense masses as this. Quotation is made in Bulletin 60 from one of the publications of the United States department of agriculture which gives an account of how the immense hordes of caterpillars stopped the trains on the Carolina Central Railroad. Great armies of the worms as they crossed the railroad tracks were crushed and so lubricated the rails that the wheels of the trains got no hold. On at least two Vermont roads trains were stopped during the last season in the same manner. Last June the caterpillars collected on the granite walls of the state house at Montpelier and on the posts of the fence which surrounds the grounds. For about two weeks a man was constantly employed in going about with a large pan in which kerosene had been poured and a small broom with which he brushed the full grown worms into the pan. During the time he worked he reports that he collected ten bushels and, as I saw the results of his work at different times, I do not think the report exaggerated. This shows how abundant the pest was in one locality. Unfortunately there are many towns in the state which were as badly infested as was Montpelier, so that the almost incredible number of worms collected there is not to be considered as altogether exceptional.

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[1] N. Y. (State) Sta. Bul. 159, p. 37 (1899).

II. LIFE HISTORY

Although the life history of *Clisiocampa disstria* was briefly given in Bulletin 60, yet it is probable that many will be glad to learn all that they can concerning so important an insect; hence the following full account. Unlike many of our worst foes this is a native species, and, as we have seen, it has been well known as a pest for many years.

THE EGGS

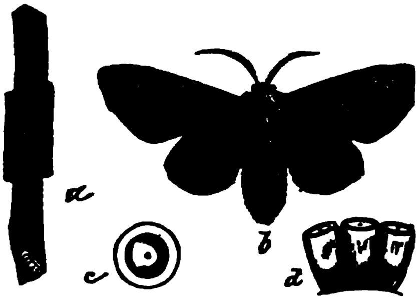

Figure 1. a. Egg mass. b. Female moth. c. d. Eggs greatly magnified.

The eggs are always placed in a band around one of the smaller twigs which presents the appearance seen in figure 1. The number of eggs in each cluster varies considerably, some containing as many as four hundred, while others may not have more than two hundred. Usually but a single egg mass is found on a twig, but there may be two or even three. The following account by Riley explains the method of depositing the eggs:

"These eggs are deposited in circles, the female moth stationing herself for this purpose, in a transverse position across the twig. With abdomen curved she gradually moves as the deposition goes on, and when one circle is completed she commences another—and not before. With each egg is secreted a brown varnish which firmly fastens it to the twig and to its neighbor, and which upon becoming dry, forms a carinated network of brown over the pale egg-shell. These eggs are so regularly laid and so closely glued together and the sides are often so appressed that the moth economizes space almost as effectually as does the honey bee in the formation of its hexagonal cells."[1]

Lowe[2] states that the egg-laying is not always as thus described and that none of the females which laid in his laboratory "placed themselves in a transverse position across the twig, but stood lengthwise of it, or nearly so, and moved sidewise while depositing the eggs. When one row was finished the next was immediately commenced. * * * With each egg an abundance of frothy glue was discharged, completely covering it and hardening almost immediately. The females died within a few hours after completing oviposition."

These egg clusters are deposited late in the summer, in this region usually not before the middle of July. In a season which opens earlier than common, and in which, therefore, the eggs hatch sooner than usual, the moths may be ready to deposit the eggs by the first of July. So far as external appearance goes, the eggs remained unchanged until the following spring, but in fact they begin to hatch not very long after they are laid, and before the close of the season the larvæ are fully formed. They do not leave the eggs, however, until spring.

When separated from the cluster, each egg is of the form shown, much magnified, in figure 1, *d*. The lower end is narrower than the upper and is rounded, while the upper is cut off squarely. As *c* in the figure shows, the top of each egg is bordered by a flat rim within which the surface is concave. This depression increases as the larva developes. Each egg is about five-hundredths of an inch long and three-hundredths in diameter across the top.

LARVA OR CATERPILLAR

After the little black caterpillars have left the eggs, which they do very early in the spring, it is astonishing how much cold and inclement weather they can endure. Some of them are always out of the shell and creeping over the twigs long before freezing weather has passed and, of course, before the leaf buds have begun to open. Nevertheless these apparently tender creatures do not perish from cold and hunger as one would suppose they inevitably would, but live on ready to attack the leaves when at last they expand. Any unusually mild day in spring is sufficient to bring out numbers of them. Although voracious feeders when food is at hand, they can at any period of their lives endure prolonged fasting. I have had caterpillars from one half to two thirds grown live in the laboratory with no food whatever for over two weeks without apparent suffering.

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[1] Riley, Insects of Mo. Rpt. 3, p. 121 (1871).

[2] Loc. cit. p. 40.

In an ordinary season the egg masses are for the most part deserted by the last of April, although as was noticed above, some of them are empty three or four weeks earlier. In other words the egg masses do not all hatch at the same time there being three or four weeks interval between the earliest and latest. When first hatched, the little caterpillars as they huddle together on the twigs appear almost black. They are about a tenth of an inch long and rather slender. The body is covered, but not thickly, with long grayish hairs. The first food seems to be the covering of the egg mass. Speaking of the tent caterpillar Lowe [1]says that "about one hundred caterpillars hatched in a cage in the laboratory subsisted for six days upon

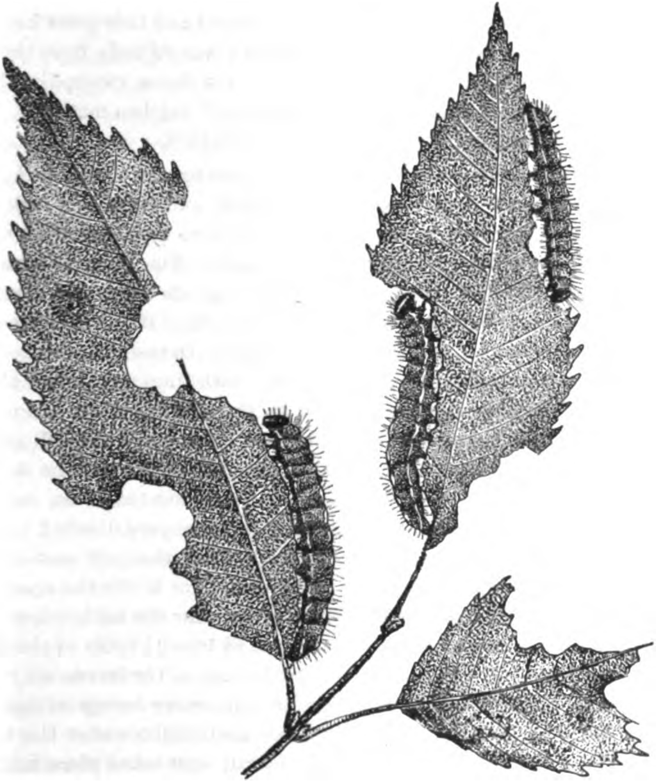

FIGURE 2. WELL GROWN CATERPILLARS FEEDING

Showing usual position when eating. After Weed no other food than the frothy glue that protected the eggs from which they hatched." The same is true of the caterpillars of this species.

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[1] N. Y. (State) Sta. Bul. 152, p. 283 (1898).

As the little caterpillars wander about the twigs they spin delicate threads of silk so that after a time the branches which they have most largely occupied are covered with the whitish threads. If they are disturbed by jarring the branches, the little worms let themselves to the ground by a thread of the same silk. This habit of spinning continues until maturity, though much less of it is done in the later stages than in the earlier.

The growth of all caterpillars is extremely rapid and this great increase in size is too much for the elasticity of the skin; accordingly from time to time it bursts open and slips off, or is shed. In the forest caterpillar there are usually four changes of skin, or molts, before it reaches maturity, and after the cocoon is finished, a fifth and last molt occurs.

As we have seen, the caterpillars just from the eggs are very dark, but in a few days they grow lighter except at the ends, and there is a dark line along each side. After feeding and growing for two or three weeks the larvae lose their old skins and appear in new ones. The interval between the hatching and this first molt undoubtedly depends upon the weather and the abundance or scarcity of food. At this time the worms are half an inch long. The color has changed somewhat with the change of skin, for now there are two light lines just above the dark lines mentioned above and these light lines become more evident as the worm grows. In many specimens, the line of light spots, so prominent a feature of the full grown worm, is indistinctly seen. About a week after the first molt the second occurs. The worms have now increased to three fourths of an inch in length. The row of light spots along the back becomes very distinct. Along each side there is the dark line which first appeared, then above this is a white line, then a pretty blue line, or rather band, for it fills the space between the lower light line and that above it, then near the back is a yellow line, and, more conspicuous than all, is the row of 10 or 11 spots of the form well shown in plate III. At the end of another week, the larvae are ready for a third molt. This brings little change in appearance except in size, the length now being an inch. The markings are also brighter after the third change of skin. In about two weeks the fourth molt takes place and the worm is fully grown. The color and markings have not changed essentially since the previous molt, but the length has increased to nearly or quite two inches, as shown in figures 2 and 5.

In figure 5, *a*, which gives a view of the upper side of one segment, enlarged about twice, the conspicuous oval or diamond shaped spot is seen and behind it a small spot of the same color, on a ground of black. On either side is seen the yellow line and beyond this—as the figure gives it—

above and below, is the blue band, seen better in *b* of the same figure. As seen in *b*, which shows an enlarged side view of a segment, there is a second and usually lighter line below the blue band. The under side is dull greenish with a large dark spot on each segment except the two front ones. As the illustration shows, the back is more or less covered with rather thinly scattered hairs, which are light, reddish brown, or almost black. The whole body is sprinkled with black dots.

THE WEB

This insect has long been called the tent-caterpillar of the forest, but it makes no real tent and very rarely seeks shelter in the mat-like structure which it does make. Still I think that some writers have not given the caterpillar credit for making as much of a web as it often does construct. It certainly never makes so conspicuous a web as does the ordinary tent-caterpillar so common on apple and cherry trees, but it seems to me a decided mistake to say that "they never make any tent or nest," as one of our best entomologists asserts; for while in a sense, this is true, yet to the ordinary observer the matted web often seen would be regarded as of the same sort as the real tent of the allied species. And not infrequently the web of the forest worm is by no means an inconspicuous object.

It is not usually located on the smaller branches, as is the web of the tent-caterpillar, but on a large branch or, perhaps more often than elsewhere, in the crotch of two large branches or of a branch and the trunk. Still, I have occasionally seen webs on the twigs. Just why this species spins a web is not altogether plain for it very seldom makes much use of it. I have killed caterpillars in or under the web, but this is the exception; more often they may be found clustered on it, though very frequently they cluster where it is most convenient and pay little attention to the web. The web is, usually, not white, but appears much as if thickly dusted with iron rust. Plate I shows a nest of the apple tree tent-caterpillar bearing the clustered insects of both species for now and then the forest caterpillar takes refuge in the tent of the allied species. I do not think that the forest caterpillar ever makes so much of a web as that shown in plate I; nor is its web stretched across several branches as shown in the figure.

CLUSTERING HABIT OF THE CATERPILLARS

Plate III and figure 3 will recall a sight familiar to many of the residents of Vermont. These figures well show the customary position of the caterpillars when at rest during the brighter and warmer parts of the day. They also collect in this manner when ready to molt. At all times until the last molt, the insects are very sociably inclined, not only seeking each other when at rest, but feeding in company as well.

In this state the full growth is attained by the caterpillars by the middle or last of June or in about six weeks from the time of hatching. This period is not however invariable, for those larvæ that come out of the eggs very early do not develop as rapidly as those that come out when food is more easily obtained and abundant and the weather is more favorable.

While the forest caterpillars may feed at any time, by far the larger part of their eating is done at night or during cloudy days. Weed[1] notices that "the caterpillars commonly eat through the leaf in such a way that the outer end drops to the ground." This is shown in the lower leaf in figure 2. This is especially true when they are feeding in groves or where trees are near together. It is the continual dropping of the bits of leaves as well as of the excrement of the caterpillars that causes the sound like pattering of rain which is often heard where the insects are numerous.

When the caterpillars have ceased to feed, they soon lose their social disposition and, no longer collecting in large masses, they wander nervously hither and thither, leaving the trees where they have up to this time contentedly fed and appearing about houses, sidewalks, fences, etc. After several days of this wandering each selects a place in which to spin its cocoon and then its journeyings are at an end.

FOOD OF THE CATERPILLAR

Like most insects, and all moths, this species does no injury except in the larva, or caterpillar state. Weed[2] gives a list of between thirty and forty trees and shrubs the leaves of which the caterpillars are known to eat, but this list might as well be increased until it includes nearly all the trees growing in any given locality, for there are few that they do not attack at one time or another. Some kinds of trees however, are much more to the taste of the caterpillars than others. In this and adjoining states, during the last few years the maples have suffered far more from their ravages than any other trees. So much has this been the case that in many places the insect is known by the name of maple worm. In other states, however, the oaks have been most attacked, elsewhere the blue gums or poplars and sometimes apple trees are preferred. In some groves of various species of trees which were attacked last year all were defoliated alike. Still it is as an enemy of the sugar maple that it has attracted most attention in Vermont.

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[1] N. H. Sta. Bul. 64, pp 83-84 (1899).

[2] Loc. cit., pp 86-87.

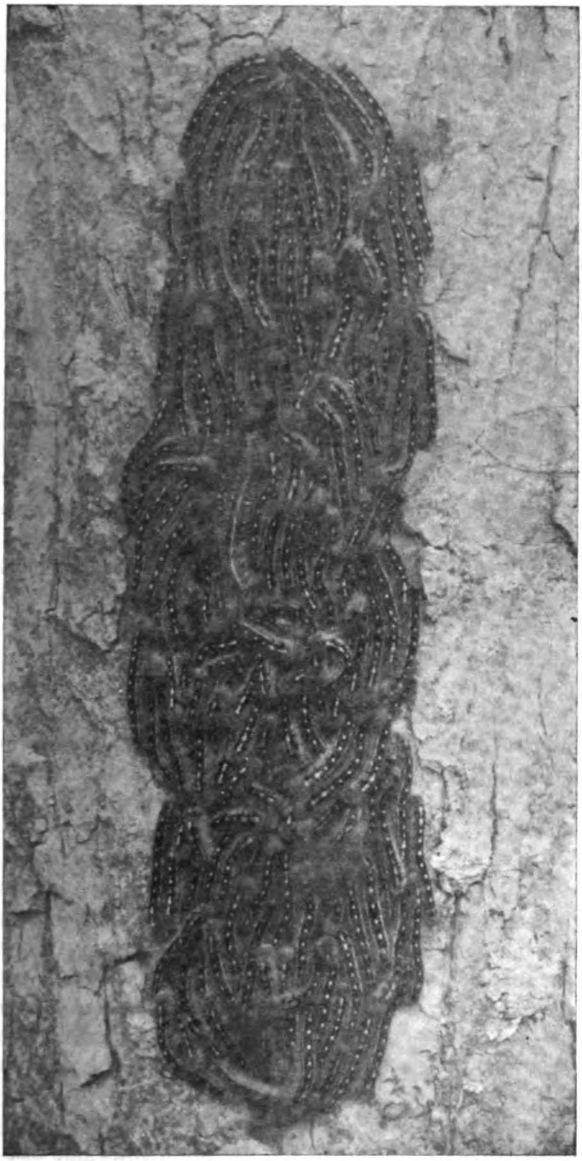

FIGURE 3. CLUSTER OF FOREST CATERPILLARS ON THE TRUNK OF A TREE
After Weed

THE COCOON

Having chosen a suitable location, such as under the edges of the clapboards of a house, which is a favorite place, or some corner or angle made by the outside boarding of a building, or, if in a grove, on the underbrush, the cocoon is spun. If it is located on a shrub, it is almost always protected by one or two leaves is in figure 4. The cocoons are quite variable in size, but an average one is from an inch to an inch and a half long and half as thick. The outside of the cocoon is light yellow and is coated with a yellow paste which soon dries to a powder. The inside, like that of all cocoons, is very compact, but the outside is quite loosely made, and with the silk fibers there are often intermingled some of the hairs of the caterpillar. The compact, parchment-like inner portion is so made by a thick fluid which fills the spaces between the thread and hardens. Three days after it has finished the cocoon the caterpillar molts for the fifth and last time and changes to a brown pupa, or chrysalis, about three fourths of an inch long. Its color varies considerably. I have seen some which were very light brown, but more which were dark brown or chestnut. The cocoons are not usually formed here before the first of June and most of them not till a week later.

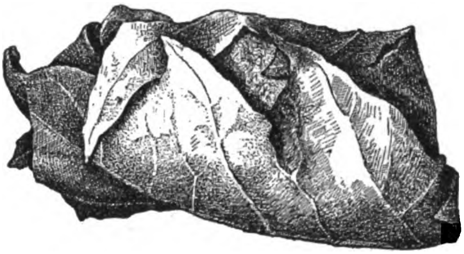

FIGURE 4. COCOON OF FOREST CATERPILLAR WRAPPED IN A MAPLE LEAF
After Weed

THE MOTH

The perfect insect or moth appears about two weeks after the cocoon is finished. If the cocoon is completed about the middle of June, which is the average time here, the moth emerges the first of July. All do not appear at once, but they come out from time to time for a week or more and are seen flying from the first of July until October. The form and marking of the moths may be seen in figures 7 and 8 and especially in plate II which shows not only the customary appearance of the moth, but several varieties.

The female moth (second row, right hand moth third row, plate II) is much larger than her mate (upper and two lower rows and two left hand in third row, plate II.) There is some variation in size, but usually the female is not far from an inch and three fourths across the expanded wings, while the male is only an inch and a quarter or less. The wings are also somewhat different in the two sexes. In both the general color of the body is yellowish brown, darker in some specimens, lighter in others (note lower row plate II, gradation from light to dark tints); and in some there is a decided reddish cast. Running obliquely across the front wings, are two lines, well shown in the figures, which are much the color of iron rust.

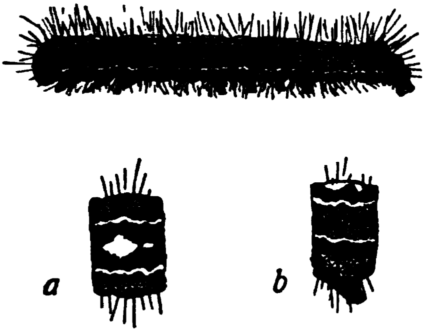

FIGURE 5. LARVA OR CATERPILLAR OF THE FOREST CATERPILLAR
a. Upper part of one ring b. Side of ring
After Weed

Very soon after coming out of the cocoon, the moths pair and the females lay the eggs on the twigs of some tree in the manner already described. The following dates are furnished by Prof. H. M. Seely of Middlebury: June 8th, first cocoons observed. June 9th, considerable number of caterpillars beginning to spin. June 13th, large numbers spinning. June 17th, some caterpillars changing to pupae, some still spinning, but most in cocoons. June 30th, first moth seen. July 1st, many moths seen. July 5th, picked egg cluster from maple tree. These dates are for 1899, but are a fair average for this region.

DIFFERENCES BETWEEN THE FOREST CATERPILLAR AND THE APPLE TREE TENT-CATERPILLAR

The frequent association of these two species has already been noticed, but a more detailed comparison will be useful. Figures 5 and 6 show plainly the most obvious differences seen in the fully grown larvæ, especially at *a* and *b* where the markings on a single joint are shown enlarged. In Figures 7 and 8 are seen moths of the forest caterpillar while Figures 9 and 10 show the moths of the tent caterpillar. Plate I also shows the two species clustered on the web of the tent caterpillar. A careful study of these figures will enable any one to distinguish one from the other. The most easily noticed character in the larvæ is found in the light marking along the back. In the tent caterpillar there is a continuous line, while in the forest caterpillar, there is not a line, but, as figure 5 shows, a row of

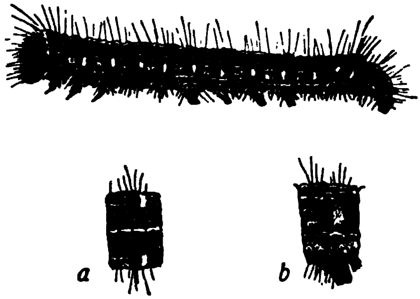

FIGURE 6. LARVA OF THE TENT-CATERPILLAR
a. Upper part of ring. b. Side of one ring
After Weed

spots ten or eleven in all. This is also well shown in figure 3. In the moths, the rust red oblique lines on the front wings of the forest caterpillar are replaced in the tent caterpillar by similar lines of a dingy white. There are numerous other differences, but the above are sufficient for ordinary use. It may be well to add, however, that it is usually not difficult to distinguish the two species even by the egg clusters. That of the tent caterpillar is thinner at the ends than in the middle so that it is oval in general outline. The egg cluster of the forest caterpillar is of nearly uniform diameter throughout, as figure 1 shows, the ends instead of sloping down to the twig, appearing as if cut off squarely.

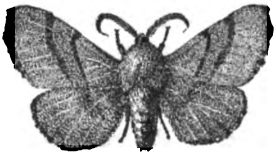

FIGURE 7. MOTH OF THE FOREST CATERPILLAR. Male, natural size After Weed

III. RAVAGES IN VERMONT

While the outlook for the coming season is not as assuring as could be wished, yet there is great reason for hope that the ravages of this insect will not be as great as they have been during the last three years. During the summer of 1899 the writer visited many of the towns in different parts of the state and in most, though not all, of these the damage done by the caterpillars was said to be less than it was during the preceding year. Still many rows of trees along the streets and many maple groves presented a most pitiable appearance.

I think that I can give an accurate account of the doings of the caterpillars in the state in no better way than by quoting extracts from a few of the many letters which have been received from those who have had only too good opportunities of observing this insect.

Miss Anna C. Brackett writes from Stowe as follows:

"I send you a report of the ravages of *Clisiocampa disstria* for the year 1899. It was very much worse than last year, in the village, so that many of the people who last year did not pay much attention to the cocoons on their buildings are very much alive now to their presence. The number of the worms in the village was so great that the village authorities took hold of the matter and had all the trees alongside of the road covered with bandages of burlaps and these were kept well tarred. The trees therefore do not look very badly there. In the woods and sugar orchards the damage has been very great, though some of the places that were

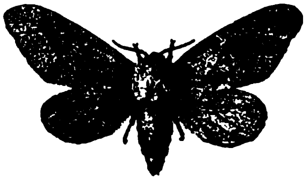

FIGURE 8. MOTH OF THE FOREST CATERPILLAR Female, natural size After Weed

attacked last year have gone free this year while other places that escaped last year have suffered severely this year. They have eaten every green tree and bush, I think, except the cut-leaved maple and the sumachs which do not seem to have been touched. The cocoons are on every sort of tree, not excepting these two.

There have been very many small sized worms this year and also many that did not seem able to spin a fine and finished cocoon. This has seemed to indicate to me that perhaps they were not so vigorous as last year. They have seemed more lazy. Very many of the pupae in the cocoons are destroyed by parasites. I find in them small black flies and also small, very brilliantly red beetles and a large proportion of the pupae are eaten, and will never rise to the dignity of millers. The worms seem to have taken to syndicates this year, two or three spinning together in one leaf as if they needed help. Many of them spin nothing but the yellow cocoon, omitting to spin the blanket of silk which they ought to begin with.

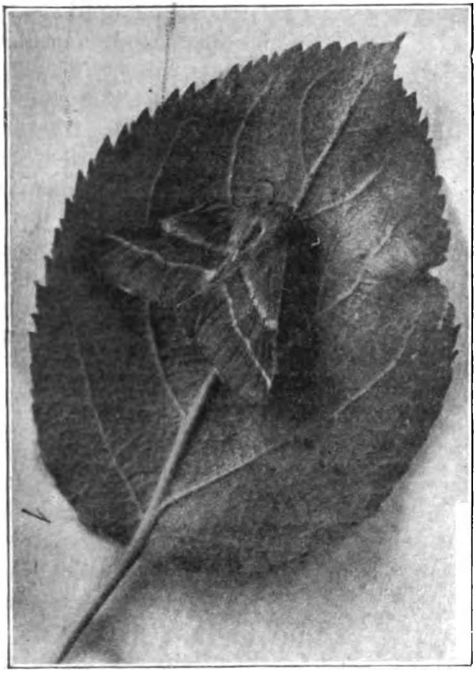

FIGURE 9. MOTH OF THE TENT-CATERPILLAR
Female on apple leaf, natural size From Lowe

The warfare with them has been almost hopeless this year. It has been pitiful to see a farmer struggling day after day with his little orchard of apple trees while forced meantime to see the destruction of his maples."

I may add to the above that the most sorry looking maple groves that I saw in 1899 were in and about Stowe, and I doubt if anywhere in the state greater damage was done than in that region.

Mr. W. J. Morse writes that "*Clisiocampa disstria* has been an unwelcome guest for two seasons in great numbers; for how much longer I do not know. Considerable damage was done in 1897 and the trees were practically stripped in 1898. The favorite trees appear to be the maple, apple and elm. The latter were not eaten so badly as the others. They came upon us from the south and in the valleys first, and are gradually working towards the mountains. They worked on higher ground last year than the year before. My observations extended through the towns of Waterbury, Stowe, Morristown, Hyde Park, and Johnson. In 1897 they were abundant in a small section a mile north of Waterbury Center and between that place and Waterbury. In Stowe I think a little damage was done west of the village, also in Morristown and Johnson

Last season—1898—they were very plenty all over Waterbury except on the mountains, and did very great damage. About a mile north of Waterbury Center it became necessary to sand the rails of the electric road on account of the number of worms crushed under the wheels. They were generally distributed all over Stowe and Morristown and did great damage."

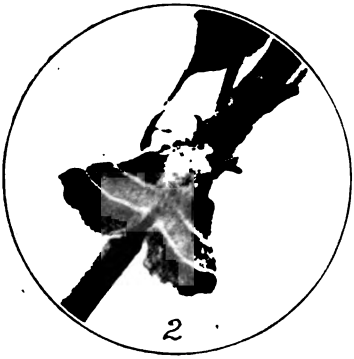

FIGURE 10. MOTH OF THE TENT-CATERPILLAR
Male, natural size From Lowe

Hon. G. S. Fassett writes from Enosburgh that "The worms first appeared in this vicinity in the summer of 1897 on the maples in one sugar grove. They did not come in great numbers, nor did they entirely strip the trees of leaves but the tops of the trees were quite badly eaten. In 1898 this same grove was almost entirely stripped of leaves, and adjacent groves, including perhaps a hundred rods north and south, were eaten quite a little, but east and west the ravages extended for more than two miles. Outside of this range very little damage was done south of me. North, on both sides of the Missisquoi river, mostly east of Enosburgh Falls village, they did more damage, notably on the farm of Merrill Jeffords. His sugar place was stripped bare as in winter and did not leave out much the second time. This last strip was wider north and south than the one first mentioned. Its length was about the same. While the worms were all about more or less, these two strips embrace most of the apparent damage done in this town."

The above accounts might be multiplied, but they suffice to show the character of the pest and its ability to commit most serious depredations.

There is no doubt that during 1897, 1898 and 1899 hundreds of acres of maple groves were very largely defoliated and some of them lost their leaves each of the years named. Mr. E. H. Ripley writes from Mendon: "There are in the valley of the Otter sugar orchards that have been

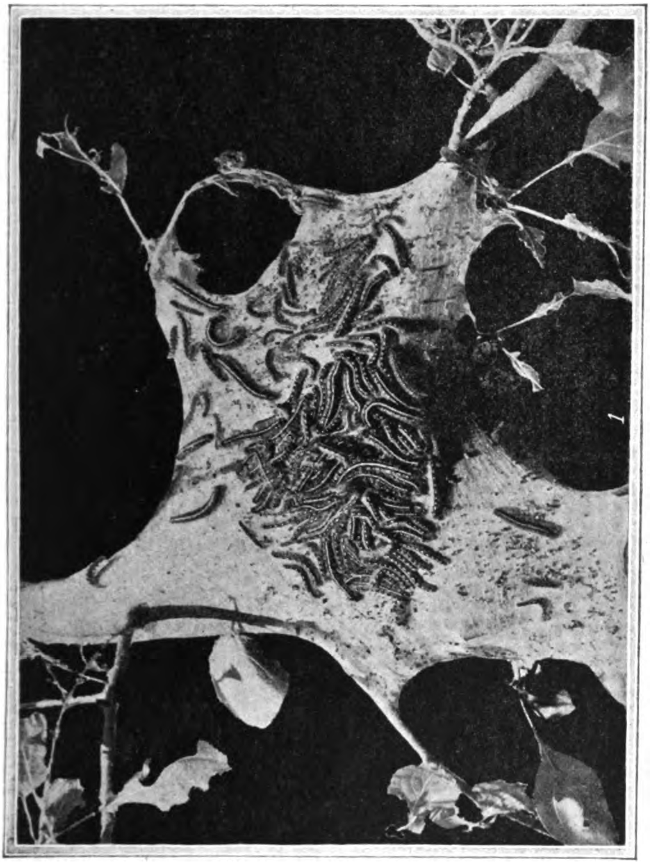

PLATE I. WEB OF TENT-CATERPILLAR

On which both forest and tent caterpillars are resting. From Lowe.

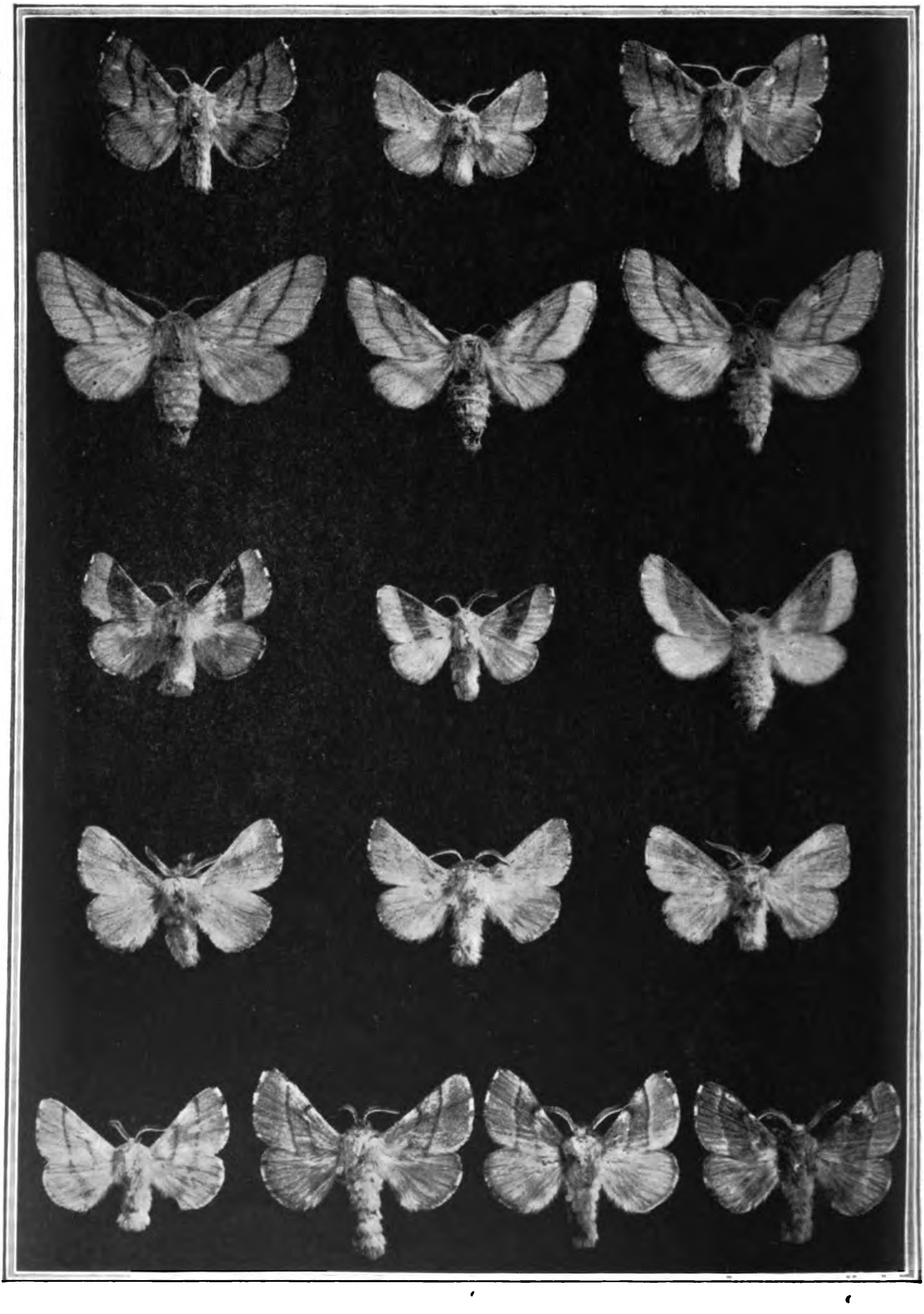

PLATE II. MOTHS OF THE FOREST CATERPILLAR

PLATE II. MOTHS OF THE FOREST CATERPILLAR.

Upper row, male moths. Second row, female moths.

Third row, variety *sylvatica* of *clisiocampa disstria.* First two on the left, males, right hand, female,

Fourth row, variety *thoracicoides*, males.

Fifth row, gradation from light tinted moth on left to dark on the right, males.

By courtesy of V. A. Lowe, Geneva, N. Y., Station.

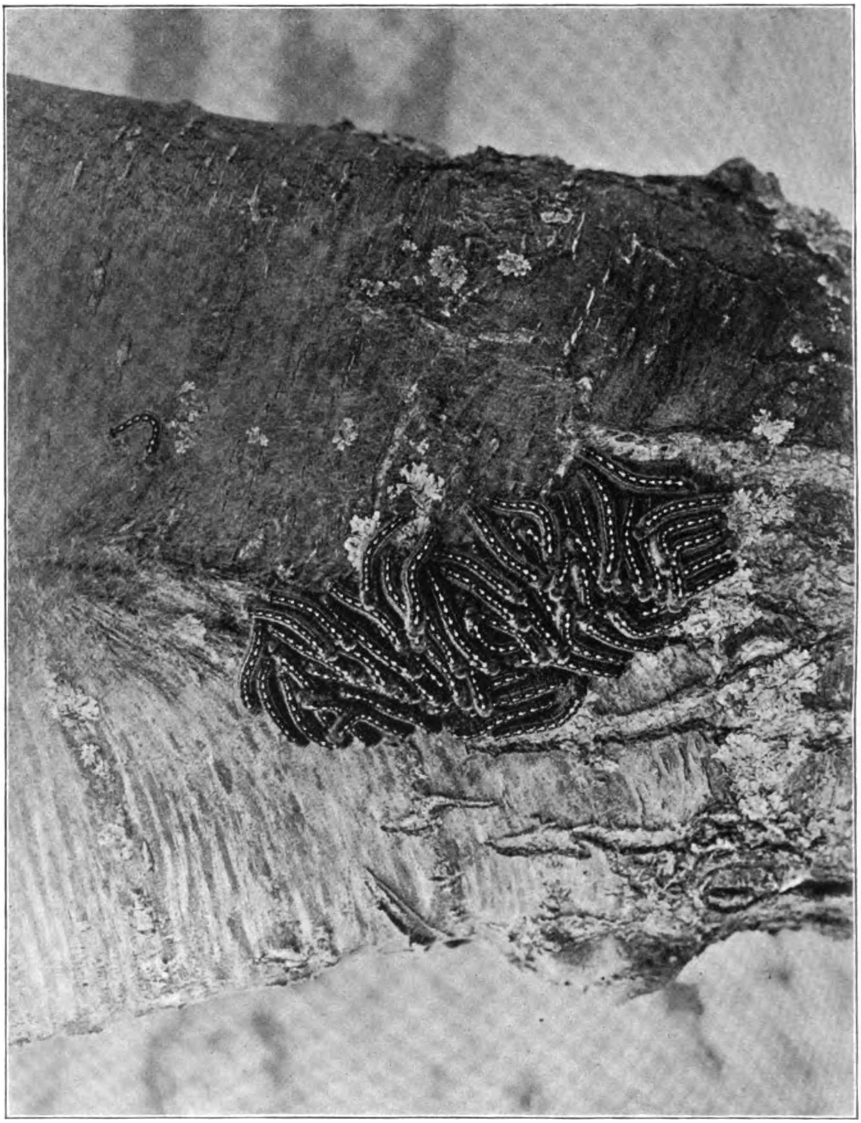

PLATE III. NEARLY MATURE CATERPILLARS CLUSTERED ON THE TRUNK OF A PLUM TREE

Courtesy of V. A. Lowe

stripped for three years and the ends of the branches have died from the loss of foliage." Mr. Lyman Hutchinson writes from Randolph: "My sugar orchard was the first to be attacked by forest worms in this section. Two years ago in June (1898) it looked as though fire had burned the foliage over the whole wood lot, and again last year they took what trees survived the first trimming. Now it is a fact that the first year's trimming killed more than two hundred out of eight hundred trees. And the result of the last trimming is that I have not two hundred trees in my orchard that have life enough left to ever run sap for sugar. We have cut from one to two hundred of those maples. The most of them were entirely dead, the rest had only a few lower limbs alive. The wood of these maples turns very dark colored before the tree is entirely dead, which injures it very much for lumber. Two years ago my orchard was about the only one in this section on which the worms worked, but last season they took a clean sweep. Every sugar place around is being cut down as fast as possible." It is very probable that some other destructive agency has been at work in Mr. Hutchinson's maple grove, for a single defoliation would not alone destroy the tree if they were in good condition at the opening of the season. Hon. V. I. Spear of Randolph also writes: "I know of quite a large number of trees that have died as a result of being defoliated." Mr. Spear states that the maple sugar crop of 1899 was not more than a fourth of an average crop, though he does not think that the forest caterpillar is the cause of this shrinkage so much as climatic conditions. There is no doubt that the sugar crop, which is a very important one in this state, has been less than average for several years. Nor is there any doubt that much of the shortage has been due to other causes than the defoliation of the trees by the caterpillars. Not only have the climatic conditions been unfavorable, but borers, fall canker worms and other insects have contributed to the general result. Nevertheless, when due allowance has been made for all other untoward influences, we are compelled to believe that the forest caterpillar has done irreparable harm to this state in the injury and destruction of the maples.

In order that the relation of defoliation to the life of the tree may be clear to the reader, it may be well to state that much of the material making up the structure of the plant is absorbed from the air by the leaves; that they are in part analagous to the lungs of an animal; and that their partial destruction lessens the vitality of the plant, and, also, its opportunity of food storage for tissue building. The processes of breaking down tissue continue however, and if the rate of restoration is retarded, death may ensue.

Just how severe the damage to the maple sugar interests of the state will finally prove to be can not, of course, be certainly foretold. It is hoped that the worst is over; I believe that it is, though I do not pretend to know that it is so; but it appears to be certain that Vermont will not produce the accustomed amount of sugar for a good many years to come.

IV. THE COMBAT AGAINST THE FOREST CATERPILLAR

1. NATURAL AIDS

Climatic conditions often very materially assist man in his efforts to rid himself of most insects, but the species we are considering seems to be unusually insensible to the weather and little can be hoped from this source. The first year of its appearance in this state was cool and wet, but the warm and dry seasons that have followed have to all appearance been just as favorable to its increase. The forest caterpillar has, however, a considerable list of foes among our common animals, especially among birds and insects.

BIRDS

The most important birds that feed upon either the caterpillar or moth or both, are the black-capped titmouse or chickadee, the cuckoo, redstart, robin, chipping sparrow, oriole, cat bird, vireos, cedar bird, and nuthatches; and even the English sparrow has been reported by various observers as eating the caterpillars. The chickadee is one of the most useful of our friends since it eats the eggs; and as the bird is a winter resident, it is able while the foliage is off the trees, to find and destroy a vast number of eggs. Weed[1] states that "the nuthatches, according to Miss Soule's account 'would stand by a patch of larvæ lying close together below a tar band on a tree and eat so voraciously and with such an entire abandonment of self-consciousness that I could go close and put my hand on them before they would fly.' The nuthatches and chickadees also tear open the cocoons and eat the pupæ inside."

It is very probable that the list of birds which feed upon the forest caterpillars might be greatly extended.

INSECTS

The list of insect enemies of the forest caterpillar is quite a long one. Less useful perhaps than parasitic insects, though not to be overlooked, are certain beetles and bugs that feed upon the caterpillars, especially when they are crawling on the ground. Figure 11 shows the likeness of an old friend that eats many injurious insects and may represent the whole group, though its members vary much in size and appearance.

Far more useful in helping to diminish the numbers of the pest are the parasitic insects. There are two groups of these, one of which is composed of insects allied to the flies, and one allied to the bees, wasps, etc. Figure 12 shows the species that has been most commonly at work in this state, though an allied species is also found. These Pimplas are the most efficient aids we have in our efforts to destroy the forest caterpillar and also the tent caterpillar. This parasite lays its egg in the cocoons of its host, the intruded egg soon hatches and the larva from it proceeds to devour the pupa of the forest caterpillar. In many parts of this state during 1899, a large number of the cocoons were occupied by the Pimpla. Lowe[1] reports that only about twelve per cent of the cocoons under observation in his laboratory in 1899 were parasitized. In a lot of several hundred which I obtained in Addison county, only a third developed moths, the rest being destroyed by the Pimplas. In one lot of two hundred cocoons hatched in our laboratory but thirty moths came out, the rest being parasitized. This is a most encouraging result, only fifteen per cent of the cocoons reaching the last stage, while eighty-five per cent were destroyed. In this case the parasite was *Pimpla conquisitor*, figure 12. I have received letters from several parts of the state stating that a large proportion of the cocoons were destroyed by parasites. Inasmuch as it is the universal rule in such cases that the parasite increases so long as its victims are abundant, we may confidently hope that the coming season will not be as the last, but that all over Vermont the trees will have a chance to put forth and retain their leaves with much less injury from the caterpillars than for several years past. Such of the lot of cocoons above mentioned as matured produced a far greater number of males than females. This may have been merely accidental, but

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[1] Loc. cit., p. 92.

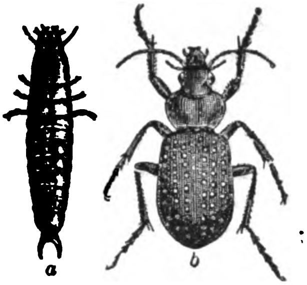

FIGURE 11 CALOSOMA CALIDUM
A beetle which devours the forest caterpillar *a*. Larva *b*. Mature beetle

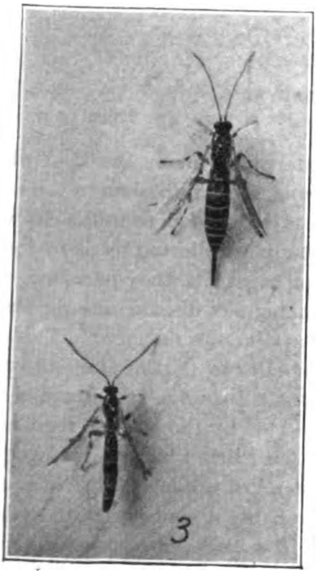

FIGURE 12 PIMPLA CONQUISITOR
Male and female, natural size The most useful parasite of the forest caterpillar From Lowe

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[1] Loc. cit., p 41.

it would be pleasant to find that the Pimpla had especial predilection for female cocoons.

Whether in this respect or not, in others the parasite does certainly exercise discrimination as to the place where she deposits her eggs. It is very interesting to watch one of these Pimplas when placing her eggs in the cocoons. She is so intent upon her task that one has no difficulty in observing her closely. She is quite brisk even to nervousness in her movements, flying quickly from one cocoon to another, hastily, but sharply, inspecting each. If the larva inside has not finished the spinning and its last molt she does not leave an egg, but flies off to the next cocoon. If the cocoon is done and the chrysalis formed, she then places herself over one end and strongly arching the abdomen thrusts her ovipositor into the chrysalis. Then by two or three successive thrusts she works the egg deeply into the unfortunate victim, withdraws the ovipositor and flies away. Sometimes she will examine and leave several cocoons before she finds one that she considers a fit place for an egg, but often the eggs are deposited rapidly. I have seen five cocoons thus parasitized in less than as many minutes. In rare instances, both moth and parasite come from the same cocoon both apparently well developed.

DISEASE OF THE LARVAE

Forbes[1] writes : "The forest tent caterpillar, an outbreak of which species occurred last year in southern Illinois, was again seen in the same region this season, but in number so greatly reduced as to inflict little, if any damage. The condition and fate of examples collected by us in southern Illinois this year and kept in breeding cages till they perished, confirmed my supposition of a destructive contagious disease among them, apparently the principal cause of their disappearance last year. This was one of the diseases know as muscardine, similar to that of the silk worm occasioned by the well known fungus *Botrytis bassiana.*" I have seen a number of caterpillars that seemed to be affected by the disease mentioned above and Weed[2] apparently thinks that it has existed in New Hampshire. There is also a bacterial disease which has attacked the caterpillar in several states and this also is found here. Most probably it is one or both of these diseases which have attracted the notice of several correspondents who have written of "sick caterpillars." On some of the trees which I examined last season there were many diseased caterpillars. Thus we may cherish the hope that at least some aid will come to us in this way, how much we can not as yet estimate.

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[1] S. A. Forbes, Insects of Illinois, State Entomol. Ill. Rpt. 3, p. 13, (1885).

[2] Loc. cit. p. 92

2. REMEDIAL MEASURES

As might be expected in the case of an insect so destructive and widely distributed the methods which have been devised for its extermination are numerous.

DESTROYING THE EGGS

During the winter the only plan that can be successfully carried out is the destruction of the eggs. Many persons seem to consider this impracticable, but so far as I know, wherever it has been at all thoroughly tried it has proved unexpectedly efficient. As a preliminary encouragement it is well to remember that each egg cluster destroyed lessens by from two to four hundred the numbers of the caterpillars for the following season. Although the eggs are not very noticeable to a casual observer, yet as soon as one has learned where to look for them and does look they are readily seen when the trees are leafless, and many may often be gathered in a short time. Where the trees infested are of low growth, as apple or other fruit trees, this method is to be highly recommended. Even if the trees are large, many eggs can be reached with a pair of long handled pruning shears, and even a sharp knife attached to a long pole would secure not a few. Of course the insect can not be wholly eradicated by this method, but in many places it would surely be very much checked. The plan of setting children at work to gather the eggs has been tried on a small scale in this state, but, far more extensively elsewhere. The following quotation, from Weed[1] illustrates what may be done in this direction, as it shows what has been done:

"In the village of Newfields, N. H., the Improvement society offered the school children ten cents a hundred for all the egg masses, or 'caterpillar belts,' as they are locally called, that they would bring in. Many of the children worked faithfully and when in February I was called in to point the moral of the process I found that 8,250 egg masses had been obtained." Anyone can multiply the above number by the average number of eggs in each cluster, say 250, and see how many caterpillars were thus destroyed at a total cost of $8.25. I have cited the above, although it was the tent caterpillar not the forest caterpillar eggs that were destroyed, because there would be no difference between the species except in the location of the eggs, which in case of the forest caterpillar would be on a greater variety of trees and on this account more difficult to reach. This is, of course, an important difference, but notwithstanding, there can be no doubt that the plan could be very advantageously carried out when the eggs to be collected were those of the forest caterpillar. As to this Slingerland[1] writes: "Just such a crusade has been successfully carried out even in so large a city as Rochester, N. Y. We believe that there is no cheaper method of controlling these forest tent caterpillars in village shade trees." It is scarcely necessary to add that the time to seek and destroy the eggs is after the leaves have fallen in the autumn and from this time on until they appear in the spring. I do not suppose that it is practicable to do very much in this way in the large sugar groves, but in those that are not too large I am sure that it would pay to try it, especially if there are no other groves near by that have been infested. It seems at first thought a hopeless task to go over a large tree and utterly useless to attempt to go over a grove; but actual experience has shown that it can be done, at least to an extent that is of great value, and with less labor than was expected at the outset.

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[1] N. H. Sta. Bul. 59, p. 203–204 (1898).

SPRAYING TO DESTROY THE YOUNG CATERPILLARS

Nothing can be done in the spring, after the eggs have hatched until the leaves have opened sufficiently to allow spraying. This would not be until after the first of May. By this time the caterpillars will have ordinarily been able to do some damage, but if now the leaves on which they are feeding can be well poisoned the career of the enemy will come to a sudden end. Any tree or trees of moderate size can be effectually protected by thorough spraying. The sooner this is done after the leaves are expanded the more likely it is to be effectual, as less damage is done of course early in the season than later, and, too, the caterpillars are more easily killed when small. Indeed, some authorities assert that spraying is of little use unless done before the caterpillars are half grown. Spraying to be most effectual should be done in this state about the first of May and certainly before the end of the second week in May.

Probably the best poison to use on maple and apple trees is paris green five ounces in a forty gallon cask of water, to which is added a pint of fresh lime water. Arsenite of lead, which has been very extensively and successfully used by the Massachusetts gypsy moth commission, is excellent for all sorts of trees and is less likely to injure the foliage than paris green. This can now be bought from almost any large dealer in insecticides. Spraying will also be found useful against any leaf eating larvæ, such as the fall canker worm, so abundant last fall in many parts of the state, that may be infesting the trees in company with the forest caterpillar.

DESTROYING THE CATERPILLARS WHEN CLUSTERED

If no remedial measures have been taken until the caterpillars are well grown, it is then better to attack them with kerosene or its emulsion.

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[1] N. Y. (Cornell) Sta. Bul. 170, p. 562 (1899).

The habit this species has of collecting in clusters as already described, is of great assistance in accomplishing their destruction.

During the brighter and warmer parts of the day they are usually very easily dealt with by applying kerosene to the clustered insects. If one has the apparatus for spraying, clear oil may be sprayed on the worms or a bunch of cotton waste or any such material can be dipped in oil and the clusters patted with it. If care is exercised to get as little oil as possible on the bark of the trees, little or no injury will result. A very small amount of oil, if it is on the caterpillars, is sufficient to destroy them, if not at once in a short time. The masses of worms can also be killed by the same sort of torch as is used against the tent caterpillar. Towards the end of the caterpillar period, that is, just before they begin to spin the cocoons, a great many may be destroyed, as we have seen, by brushing them from the lower parts of the trees, fences or wherever they congregate, into a pan of kerosene. If everybody who can would see that this is done, a vast number of the caterpillars would be destroyed.

BANDING THE TREES

It should always be remembered that banding does not protect those trees on which the moths have laid their eggs. The moths fly freely in the latter part of the season and place the eggs, in the manner described on a preceding page, on the twigs, and for this reason, the tops of trees are most severely damaged. The caterpillars that hatch from an egg cluster begin to feed on the nearest leaves and do not generally leave that tree so long as there is abundance of food; but if a tree is nearly stripped of leaves, or if the branches have been jarred, they creep down the trunk, or drop to the ground, and then soon seek another tree. When the caterpillars are small, they may be easily jarred from the branches on which they are feeding, and small trees may be cleared of them in this way, but when nearly grown they do not so readily drop from the tree. Banding, is, therefore, useful only as it prevents those caterpillars that have left the tree on which they were hatched from crawling back or getting at the foliage of an uninfested tree. I do not mean in saying this to disparage banding, for it is often very useful and I wish to recommend it. It must, however, be properly done and at the proper time. I have seen not a little banding in this state that was absolutely useless because it was not done in time. It must be obvious to any one that banding can be of no use after the caterpillars have begun to spin their cocoons; and yet I have seen bands applied with considerable trouble after every caterpillar had ceased to crawl for that season. Bands should be applied to the trees not later than the middle of May and it will be better to get them on by the first of the month for at any time caterpillars are likely to be jarred from trees and the bands will prevent them from going back. As the worms do not creep up the trees after the last of June and usually not after the middle of that month there is no need of keeping bands on the trunks after that time.

A great variety of materials have been used with more or less success. No one form of band, or particular substance spread upon the bands, appears better than all others. Several sorts appear to be about equally effective. There is more difference in the cost of different kinds than in their utility. The common sticky fly paper was extensively used in several of our larger towns last season and, so far as I could see, was very convenient, and effectually prevented the caterpillars from going up the trees. Bands of tarred paper smeared with lard or any grease, are good. Some persons mixed sulphur with the lard, but I do not think this of any additional value. Burlap bands, around which is placed a strip of tar mixed with two parts of oil, are cheap and effective if the tar smear is not too narrow. It should be at least three inches in width. Tar alone, either coal or wood tar, soon hardens and then the worms go right over it. The caterpillars can seldom cross strips of cotton wool if they are three or four inches wide; but if this material is used it must be carefully adjusted and well fastened to the trunk, or the wind will break it so that spaces through which the caterpillars can creep will be exposed. The neatest bands of this sort that I have seen were made of strips of sheepskin tanned in the wool. These appeared to be efficient and they certainly presented a much more tidy appearance than any other bands. There are two patented compounds of, I judge, coal tar and other substances, which are easily applied on bands and remain fresh for some weeks. These are Dendrolene and Raupenleim. They can be placed directly on the bark of the tree if it is not too young, in which case it may injure the tree and should be put on a paper or other band. On old trees the rough bark may be scraped smooth in a belt three inches wide around the tree and then the mixture smeared on with a knife or stiff brush. Probably the Raupenleim is the better of the two though Dendrolene is cheaper. The former can be bought of William Menzel & Co., 64 Broad St., N. Y. for $1.00 per five pound can or of the Bowker Fertilizer Co., Boston. The chief objection to the use of this material if applied directly to the trees is that it remains a disfigurement for a long time. A strong potash wash will, however, remove it. If paper bands are first placed about the trees and the Raupenleim put on these the objection does not hold, for, of course, these can be removed at any time; on the whole this is the safer way to use the mixture. Various forms of metal bands have been tried, but it is doubtful whether any such band can be furnished as cheaply as the equally effective kinds just mentioned. Mr J. H. Neill of Waitsfield writes that he has used strips of tin four inches wide with good results. He nails these to the trees on the upper side leaving the lower side flaring two or three inches rom the trees and puts cotton between the nailed side and the tree to make a close fit. He thinks this sort of band would not cost more than five or six cents a tree. A very neat, and, I doubt not, entirely efficient band is one made by the Expansive Tree Protector Co., Rochester, N. Y. This—figure 13—is a wide, flaring, galvanized iron band with a felt top where it fits the tree, which can be put on or taken off in a very short time, as it is held in place by a spring and hook. Both felt and metal are coated with repellant substances. The first cost of this band is considerably more than that of most of those mentioned, but it is much less disfiguring, and can be removed when no longer needed and put away for another year. I see no reason why, as the advertisement claims, it will not last for years. If this is true these protectors would not in the long run be at all expensive, for the first cost is not great, fifteen cents for the first foot and five cents for each additional foot. These bands can be bought from Mr. G. F. Wells, Burlington. The bands are made for trees of all sizes.

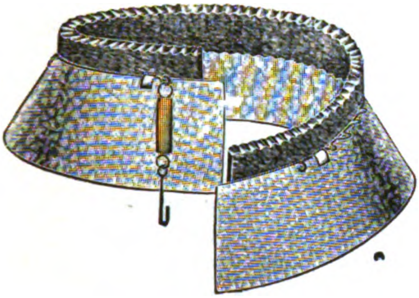

FIGURE 13. METAL AND FELT BAND
Adjustable to trees of any size. Patented 1899

Caterpillars were dislodged in great numbers from the large trees at Montpelier last spring by streams of hydrant water, and were prevented from reascending the trunks by banding. Similar expedients are reported in use in New Hampshire and New York.

DESTROYING THE COCOONS

During the early part of July much may be accomplished by collecting and burning the cocoons. Children might be employed at this work and a relatively small amount of money could often be well spent in hiring them. This is open to some objection in places where parasites are abundant, because these latter would perish with the rest. Ordinarily, however, I do not think that as much harm would be done from killing the parasites as good from the destruction of the larger number of the injurious insects. If the parasites were sufficiently numerous to make it worth while, the cocoons could be placed in a box, or barrel, and the top covered with a netting which would let the small parasites escape but not the moths as they came from the cocoons.

CATCHING THE MOTHS

This has been suggested by some writers, but I doubt if ordinarily very much can be accomplished in this way. Traps of divers sorts have been recommended, but they are not very valuable aids in exterminating the insects, though they do accomplish something. There is one trap, however which though not set for the moths, does capture vast numbers of them. The electric lights in our towns and villages are annually destroying countless numbers of insects. Last season while the moths of the forest caterpillars were most active the globes of the street lights in Burlington were sometimes a third full of insects, largely of this species.

I am well aware that the question which in this state has been most anxiously asked, How can we save our sugar places? has not been satisfactorily answered. Nor can it be. I have given all the remedial and preventive measures known, and so far as the shade and the fruit trees are concerned the methods named will prove effective, but they are not so applicable to a large grove. If a town owned a steam spraying apparatus, this might be used with success in any ordinary maple grove as well as on the shade trees along the street. A spraying machine costing $200 or $250 would be a most useful piece of property in many of our villages, and its proper use would not only preserve the shade trees, but, in most cases, prevent injurious insects from spreading from these to fruit trees. A large number of the most destructive insects can be most effectively held in check, if not destroyed, by spraying. A large spraying machine is too expensive perhaps for the ordinary farmer's bank account, but if a good apparatus were purchased by a village and rented to owners of maple groves it might be a good investment for both village and farmer. While it is not a small task to spray a hundred or more trees, it is not so burdensome as some may fancy. I think it has been the experience of most who have tried it, that when once well started, the spraying of a considerable number of trees requires less time and labor than would at first have been supposed. If a sugar orchard has not been attacked, it may be very well protected by banding, at least for that season. When, however, the trees are visited by the moths which deposit their eggs on the upper branches, then as these hatch the following season, there is no remedy but spraying. If neither spraying nor banding is practicable, then all that the owner of a maple grove can do is to hope that the parasites will be so abundant that, if not that season, then next the enemy will be routed without his help. As we have seen, this is not an idle hope. The effects of parasitism and disease are already seen in this state in the large number of cocoons which failed to develop and also in the small size of the egg clusters which has been very noticeable of late. Slingerland[1] says of New York "We visited several maple sugar bushes last year where the caterpillars had just finished stripping the foliage from all the trees and we never saw so many parasitic foes; the little ichneumons and tachina flies were surprisingly numerous and busy getting in their deadly work on the caterpillars. We hope and believe that the enemies of the caterpillars can be depended upon to get the upper hand and control the pest in the forests and sugar groves of New York in a year or two." I believe that we may say the same of Vermont.

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[1] Loc. cit. p. 561.

Certainly, if those interested will do all that they can to diminish the numbers of caterpillars by the means indicated on the preceding pages we have reason to hope that by the combined attacks of man and parasites it will not be long before all serious injury from this insect will cease.

SHOULD CATERPILLAR-EATEN MAPLES BE TAPPED?

This question is being asked frequently and earnestly.

Whether or not to tap will depend upon circumstances of which the sugar-maker is the best judge. His decision should be influenced by the following considerations. The sugar is the reserve food of the tree stored last season to feed the buds this coming spring. The amount of sugar taken from an ordinary maple tree by tapping is from two to four per cent of its total sugar content. This is so small a fraction as usually to cause no appreciable loss to the tree. But if the leaves have been so badly eaten by the caterpillars during the past seasons as to have its life endangered, it might be undesirable to make even this small drain which would somewhat decrease the chances of life for the tree.

It is to be remembered, however, in this connection that all of the stored sugar is manufactured in the green leaves in the summer and fall. Now if the leaves were eaten by insects there would be proportionately less sugar in the sap, and in case the damage to the foliage was really serious, the sap might be so low in quality as regards sugar content that it will not pay to tap the trees in any case. On the other hand, if there is enough sugar present to make tapping profitable, then there is enough so that the removal of the two to four per cent will not appreciably affect the tree.

It is believed, therefore, that the safest way for one who is in doubt is to determine the quality of the sap from his trees, selecting several representative trees and taking samples from these before tapping the remainder. If the sap is of good quality he may safely tap. If, however, it is of poor quality—that is, deficient in sugar—it will be both unsafe and unprofitable to tap.

The directions may be tersely put thus: Tap if there is sugar enough to make it pay to do so.

UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN No. 127

APRIL, 1907

State Nursery for Forest Tree Seedlings

BURLINGTON:
FREE PRESS PRINTING CO.,
1907.

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☞Copies of the reports and bulletins of the Station are sent free of charge to any address upon application.

☞Address all communications, not to individual officers, but to the Experiment Station, Burlington, Vt.

Director's office, chemical, horticultural and veterinary laboratories are at the Experiment Station building, at the head of Main street; botanical laboratories are at Williams Science Hall, University place.

Experiment farm and buildings are on the Williston road, adjoining the University grounds on the east.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 127—STATE NURSERY FOR FOREST TREE SEEDLINGS

By L. R. Jones

The General Assembly of 1906 placed a new and serious responsibility upon the Experiment station by passing the following act:

NO. 15.

AN ACT TO AID IN THE ESTABLISHMENT AND MAINTENANCE OF A NURSERY FOR FOREST SEEDLINGS AT THE VERMONT AGRICULTURAL EXPERIMENT STATION.

It is hereby enacted by the General Assembly of the State of Vermont:

Section 1. The sum of five hundred dollars per year for a period of five years, payable in semi-annual installments on the first day of April and October, beginning April first, nineteen hundred seven, is hereby appropriated for the purpose of aiding in the establishment and maintenance of a nursery for the propagation of forest seedlings of useful varieties at the Vermont agricultural Experiment station. The auditor of accounts is hereby directed to draw an order in favor of such experiment station at the times and for the amount above specified.

Sec. 2. The Vermont agricultural Experiment station shall at its own expense furnish the land necessary for such nursery and furnish the necessary expert supervision.

Sec. 3. Such Experiment station shall, as soon as may be and as far as practicable, furnish to all applicants who are residents of or land owners in Vermont, material for forest planting at, so near as can be computed, the actual cost of the same, such material to be used only for forest planting in this State.

Sec. 4. The state forestry commissioner shall furnish to any applicant for such forest seedlings suitable directions for planting the same and, so far as he may be able, when requested, he shall furnish skilled assistance or supervision for such work, the applicant therefor paying the expense thereof.

Sec. 5. Any surplus stock which may be left in the hands of such Station from time to time after the demands mentioned in section three have been supplied may be sold to parties for use outside of this State at fair market prices.

Sec. 6. This act shall take effect only in case the Board of Control of such Experiment station on or before the first day of March, 1907, votes to accept the conditions and carry out the provisions of the preceding sections.

Approved December 16, 1906.

The passage of this act has naturally stimulated inquiry as to what the Station can do and especially as to when and under what conditions it can furnish forest seedlings. The present bulletin is issued to answer these questions, at least in a preliminary way.

The Board of Control having accepted the conditions, placed the responsibility of carrying out the provisions of the law upon the botanical department. Inasmuch as it is as yet impracticable to secure the services of a trained forester the Station has profited so far as it can from its proximity to the extensive New York State nurseries situated at Saranac Lake and the New York State forest holdings thereabouts. It considers itself and its constituency fortunate in that, thanks to the courtesy of the New York Forest Commission, it has secured the appointment of C. R. Pettis, New York State Forester, to act also as consulting forester for this station. While Mr. Pettis' duties to his own state work are too exacting to permit him to give much time to Vermont's problems he will be able to advise and in a general way direct in the development of the state nursery and to aid by correspondence in advising prospective planters. The similarity of the conditions in this State and in the Adirondack region, where Mr. Pettis's experience has been largely gained and where his work for years has lain, will make his advice peculiarly serviceable to prospective Vermont tree growers.

SEEDLINGS FOR SALE THIS SPRING.

The law requires (Sec. 3) that the "Experiment station shall, as soon as may be, and as far as practicable, furnish to all applicants who are residents of or land owners in Vermont, material for forest planting at, so near as can be computed, the actual cost of the same, such material to be used only for forest planting in this State."

Of course the primary purpose of this act is to enable the Station to establish a nursery in which such seedlings can be grown at the lowest practicable cost. This will be started the present spring (1907) and some kinds of these seedlings will be ready for distribution at a relatively low price for planting in the spring of 1908. Numerous applications, however, have already been made by parties who wish to secure some small amounts of stock for use in planting this spring.

Last year the Station secured several thousand seedlings, partly by purchase from nurserymen, partly by collecting native stock, which have been carried in the nursery row one year. These were designed for planting on land belonging to the University. Some of these, however, under the present circumstances will be offered for sale at cost. Moreover, arrangements have been made with a reliable nurseryman to fill orders for seedlings of white pine and locust at as low a rate as practicable. Furthermore, it is a pleasure to announce that New York State through its Superintendent of Forests, Col. William F. Fox, has generously offered to send this spring to the Vermont state nursery some 100,000 white pine seedlings. These will be furnished at practically the cost of production and can therefore be sold here at a low price. From these various sources the Station offers for distribution this spring (1907) the following seedlings. The prices quoted cover cost of packing unless otherwise noted, but do not include express charges. In practically all cases these quotations are made upon a limited amount of stock and orders will be filed in the order of receipt so long as the same lasts. *Orders should be made by May first so far as practicable, should be accompanied by cash since no accounts can be opened, and should carefully specify the grade of goods desired.*

1. White pine, ***nursery-grown,*** 3-4 years old transplants suitable for use this spring in permanent forest plantation (size 5-8 inches). Price per 1000, $12.00.

2. White pine, ***native seedlings,*** 3-5 years old taken up last spring and carried in our nursery rows one year, (Size 6-12 inches). Price per 1000, $5.00.

3. White pine, ***native seedlings,*** 3-4 years old, to be taken up this spring upon orders. (Size 4-8 inches). Price per 1000, $3.00.

4. White pine, 2-year old, ***nursery grown*** seedlings from the New York State nursery. (Size 3-6 inches). Price per 1000 in lots of less than 1000, $2.50. Price per 1000 if in lots of 1000 or more, $2.25. (Perhaps a slightly lower figure can be quoted on large orders).

5. Common or black locust, to be purchased by the Station upon special order from a nurseryman, 1-year old seedlings suitable for use this spring in permanent forest plantation, varying in price according to size as follows:

The cost of packing these locusts will be charged in addition.

4-6	inch	seedlings,	price	per	1000	$1.75
8-12	"	"	"	"	"	2.50
12-18	"	"	"	"	"	3.00
18-24	"	"	"	"	"	3.00

ADVICE TO PROSPECTIVE BUYERS.

It is probably needless to repeat that since the above prices approximate as nearly as practicable the actual cost of the goods to the Station it has nothing to gain or lose in any way and formulates the following advice simply to guide the purchaser for his own best good.

Relative to lot 1: The price is too high to justify the use of this stock in a commercial plantation. It may, however, pay some persons who wish to make a small trial plantation this spring to secure a small number of these seedlings.

Relative to lots 2 and 3: A limited number only are offered. These plants are fully as large as those of lot 1, but the relative value of such native seedlings as compared with nursery grown stock is a matter of some doubt. The Station will be glad to supply a small quantity of either of these lots to any who wish to test them by way of experiment alongside of either lots 1 or 4, but does not recommend them other than for trial in a small way this year.

Lot 4 offers trees of the best value, thanks to the generous courtesy of New York State. These are the best of 2-year old seedlings for which the nurserymen are charging from $4 to $6 per thousand. Where conditions are in all respects favorable, these can be immediately used for the permanent plantation, but this is not generally to be recommended. For most conditions 3 or 4-year old plants once transplanted should be used. It follows that most purchasers should carry these plants in a nursery row on their own premises for one year, or if desired two years, before using them for the forestry plantation. This method will be carried out in the state nursery with as many of these seedlings as the limited funds available will permit. Such will then be offered for planting in 1908 and 1909, but of course at an advance in price sufficient to cover cost of so handling. It is to be regretted that so much of the $500 available will be required for starting seed beds that the Station cannot undertake to carry in this way as many as could be wished. Parties who contemplate the use of more than a thousand or two next year are urged to lay in a stock of these seedlings this year to be grown by them until needed for planting. It is an opportunity for lower priced stock than probably can be offered in 1908.

Directions for handling these plants in the nursery row will be supplied with the plants.

ADVICE RELATIVE TO FORESTRY PLANTING.

The profit from forestry planting if wisely done was discussed last year in bulletin 120 of this Station. It was there shown that where a perfect stand of white pine can be established at an initial outlay of not to exceed $10 to $15 per acre, including land value, it represents one of the safest and most promising of long time investments. This investment computing compound interest and taxes for 40 years becomes multiplied a little over fourfold: i. e. an investment of $12 becomes at the end of the 40-year period about $50. But at present prices and with average growth such a stand of pine would be worth on the stump three to four times that sum. If allowed to stand another 20 years the value would further increase at a still more accelerated rate. The following statement shows the possibility from second growth pine on what would be otherwise land of low value. It was prepared for publication in Bulletin 2 of the Vermont Botanical Club by Mr. Milo A. Gibson, after careful verification of the figures.

"In considering the amount of profit derived from various crops it is necessary to take into consideration the value of the land upon which the crop is raised, the cost of planting, labor in raising, length of time required and the final amount of production. In the growth of pine, which I consider the most profitable crop for Vermont, the first three considerations are reduced to a minimum; the fourth, while many times greater than in the case of agricultural crops, is less than in almost any other forest crop; the last is, under favorable conditions, enough greater than in all other cases to make pine our most profitable crop.

As an example of the amount of production of pine per acre, I will cite the case of some pine recently cut on the Gleason farm in the town of Barnet, not far from the village of McIndoes. There, in the winter of 1905-1906, eight hundred thousand feet of the finest quality of pine lumber was cut from a tract of about ten acres—eighty thousand feet per acre. An ordinary observer would have considered the pine first growth, but Mr. Roy of East Barnet, who purchased the lumber, said: 'An expert could easily detect the difference although a lot of it was equal to the Michigan pine, and, if it had been shipped from there and mixed with their output, no one could have told the difference as it was equally as good as any that comes from there.'

There were in all about 1500 trees, averaging in stump diameter from 18 to 24 inches. The largest tree which Mr. Roy kept track of sawed out 2,200 feet of lumber, and there were many trees which yielded ten 12-foot logs. The diameter of the last log was in all cases six inches at the small end. The best pine grew on but five of the ten acres so if the figures for these could be ascertained they would show a much greater output per acre. There was also upon this lot about fifty thousand feet of hemlock and an equal amount of hardwood lumber, besides about fifty cords of wood, but these last figures are only approximate as only the pine went into Mr. Roy's hands.

This is only one of many similar cases in Vermont. Why not then, when help is scarce and wages high, encourage the growth of pine, and reap a forest crop which grows rapidly, and yields large returns for a small investment of labor and money?"

This was natural growth. The most promising situations for forestry planting is where one can aid nature in such work. There are places on most Vermont farms which can profitably be devoted to tree planting; such as recently cut over land where the prospects for natural reforestation are not good; vacant spots in areas otherwise reforested by natural process; old pastures now practically valueless because of weediness or inaccessibility; or, finally, sandy wastes too barren for agricultural uses. In any case the beginner should be content to make a small trial plantation the first year unless he has the benefit of the personal advice of an experienced forester. Profiting by his experience he can later safely push the work more aggressively.

KINDS OF TREES TO PLANT IN VERMONT.

Unquestionably the white pine either in pure plantation or mixed with hardwoods like the sugar maple is the most promising tree for the most situations in Vermont. Its selection is advised for nearly all cases. It is probable that no other native coniferous tree deserves planting, unless it be the red pine and the white cedar. On situations suited to the spruces the Norway spruce is of more value than our natives, and likewise the European larch does better than the native larch or tamarack. All of these kinds will be grown in the state nursery and it is proposed later to encourage at least experimental plantation of these and other kinds which have promise. But, as said at the outset, the white pine is of pre-eminent and established worth.

The common or black locust is of peculiar value also though probably only small plantations are to be encouraged. As explained in an earlier publication[1] it is the best tree for growth on dry soils for fence posts or stakes. The stock is easily grown from seed or cheap if purchased and the trees in favorable situation make fence-post size in from 12 to 25 years and when cut reproduce by coppice growth, sprouting from the roots.

TIME AND METHOD OF PLANTING.

Early spring is the best season in Vermont for planting all of these trees. It may be done as early as the ground can be worked and may, on the other hand, be delayed with the conifers as late as the middle or even the latter part of May, i. e. until the buds start. The earlier planting is especially to be commended on dry sandy soils which may suffer later from drought.

The ideal stand requires the trees to be set as close as 6x6 feet, and many advocate as close at 5x5 feet. The former distance yields 1210 trees per acre, the latter 1742 trees. If white pine is to be the ultimate crop, maples or some other tree may as well constitute one-half this early stand providing they occur naturally or are more cheaply secured than the pines.

Since details regarding practical planting methods were given in bulletin 120 and will be sent out with each shipment of seedlings, they are not included here. Suffice it to say that the work is in general best done with the mattock or grub-hoe; and that the principal precautions necessary are to keep roots of the seedlings moist, set at natural depth and pack the soil firmly about them.

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[1] Vt. Sta. Rpt. 15, p. 239 (1901-02).

TRANSPLANTING NATIVE SEEDLINGS.

This is of course satisfactory for most deciduous trees and has been advocated by some as economical with white pine where they spring up abundantly. It doubtless will prove so in favorable circumstances, at least until the production of nursery stock either in the state nursery or by home growing is more fully developed. Such native white pines were transplanted last spring into the station nursery at a total cost of labor when set in the nursery of less than $2 per thousand. Such native stock it not, however, in the writer's judgment generally equal to well grown nursery stock and the New York State 2-year old seedlings offered at about the same price are distinctly better.

SEED COLLECTING AND SOWING.

Since correspondents are asking about the practicability of collecting and sowing pine and other seeds either in the field or in home made nurseries, the following brief statements are made upon each of those points:

No attempt is made here to give full directions for any part of this work but merely to answer the questions which naturally arise in the mind of one who is considering these operations. Bulletin 120 published last year gives the fuller directions relative to certain of these matters and another bulletin on practical forestry methods is in contemplation for publication probably before another year's work begins.

COLLECTING PINE SEED.

The demand for native white pine seed is in excess of the supply. Anyone who is favorably situated may profitably collect the seed either for his own use or for sale. This Station will doubtless wish to purchase some next year for its own use and for distribution, and in addition will be glad to advise prospective collectors as to market conditions. The pine cones or "burrs" are two years in maturing. They ripen about September 1 and should be collected between September 1 and 15. After the latter date they begin to open and scatter their seeds. In order to secure the seed the cones are allowed to dry under cover until the scales open when the seeds readily fall out or can be threshed out with a flail. A bushel of cones or "burrs" will yield on the average from 1-3 of a pound to 1 pound of seed. These are now selling at retail at from $2.50 to $4 per pound.

It is advisable to use the seed the following spring, although it will retain its vitality over one year.

BROADCAST AND SPOT PLANTING.

Pine or other forest tree seeds cannot economically be sown broadcast, owing to the high price of the seed, the loss from birds and animals eating it and the uncertainties of a uniform stand even under the best of circumstances. Thus it takes 4 or 5 pounds of seed per acre which will cost as much or more than to buy and set the plants. A better way if seed is to be used in the permanent plantation is to prepare spots 1-2 feet across and plant seed in these; but far better yet and more economical is to grow the plants in nursery rows and to transplant them to the field.

NURSERY BEDS.

Home-made nurseries are practicable, but unless one has learned by experience he may better leave this work to the state nursery or, if he tries it, begin it on small scale. The bed should be very carefully prepared and the seed is best sown broadcast and covered in some way. It germinates within a few weeks and the seedlings are to be left for two years in this bed, under partial shade the first year, and covered the first winter. At the end of the second year they are usually transplanted into the nursery row and allowed to grow there one or two years longer before used for permanent planting. Since it is presumed that few of the readers of this bulletin will be undertaking nursery bed making this spring no attempt is made here to give full practical directions. As before indicated another bulletin will doubtless be issued next winter giving fuller directions concerning the practical features of seed collecting, making and caring for the nursery bed, handling and planting the seedlings and subsequent care of the forest. Meanwhile inquiries for more detailed advice upon any of these points than is contained in this bulletin will be furnished by the Station in reply to specific questions.

UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN No. 132

JANUARY, 1908

Forest Planting in Vermont

BURLINGTON:
FREE PRESS PRINTING CO.,
1908.

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Director's office, chemical, horticultural and dairy laboratories are in Morrill Hall, at the head of Main street; botanical laboratories are at Williams Science Hall, University place; veterinary laboratories at 499 Main street.

Experiment farm and buildings are on the Williston road, adjoining the University grounds on the east.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 132—FOREST PLANTING IN VERMONT

By L. R. JONES AND C. R. PETTIS

SUMMARY.

There are large areas in Vermont better adapted to forestry than to ordinary farm crops. The profitable course in the management of such lands is to encourage natural reforestation and to supplement by judicious planting. Pages 12-13.

The best kind of tree for general forest planting in Vermont is the white pine. Other conifers worthy of trial are Scotch pine, red pine, Norway spruce, European larch. The locust is of promise as a grower of posts. Pages 13-15.

The State Nursery can furnish this spring, seedlings of locust and white pine, and white pine seed. It will advise in securing further stock from commercial nurserymen as desired. Pages 15-18.

Advice is given as to kinds of soil suited for planting, as to time and method of planting, and as to transplanting native seedlings. Pages 18-21.

Forest trees may be started from seed. Sowing the seed in the field either broadcast or in spots is not advised. It is better practice to sow it in seed beds and to transplant the seedlings when strong enough. Pages 21-23.

The State laws are summarized relative to the appointment and duties of the State Forestry Commissioner, of town fire wardens, tax-exemption of planted lands, and the establishment and duties of the State Nursery. Pages 23-24.

INTRODUCTION

Bulletins 120, issued in March, 1906, "Planting White Pine in Vermont," and 127 in April, 1907, "State Nursery for Forest Tree Seedlings," are still available for distribution on request: hence no attempt will be made in the present bulletin to discuss in detail the facts there set forth. The aim of this bulletin is rather to answer briefly the following specific questions:

1. What is the present outlook as to forest planting?
2. What are the best kinds of trees to plant?
3. What can be secured from or through the State Nursery in the spring of 1908?
4. How is forest planting best done?
5. How can forest seedlings be grown at home?
6. What are the state laws relative to tax exemption and other forestry matters?

WHAT IS THE PRESENT OUTLOOK AS TO FOREST PLANTING?

This question is clearly formulating itself in the minds of many Vermonters. An attempt to contribute to the right answer has been made in some detail in bulletins 120 and 127. Assistance has also been had in the formulation of a correct policy in forestry management from the addresses of experts at the annual meetings of the Vermont Forestry Association, and in the publications of the Forestry Commissioner. In the light of the experience of the past year the following statements are made with fuller confidence. There are thousands upon thousands of acres in Vermont which will prove more profitable for forestry than for ordinary farming. Timber lands if rightly managed will probably in the end bring a larger return on the investment than any other farm property. Nature if left to herself will clothe many of Vermont's waste lands with trees. Man should simply aim in forestry management to cooperate with nature, so directing her processes as to secure natural reforestation with valuable species so far as practicable, and supplementing this by planting where opportunity favors.

It was to economize and aid this movement that the State Nursery was established by the legislature of 1906. It is required by law to supply forest tree seedlings for planting within Vermont, so far as practicable and at the approximate cost of production. Hence last spring it offered white pine and locust seedlings of varying sizes and prices. The demand far exceeded the available supply. The details relative to this distribution will appear in the forthcoming annual report. Suffice it to say here that every shipment was reported to have arrived in good condition. The locusts were one year old seedlings, practically all of which lived and made rapid growth; and there is no reason to doubt that they will continue to prosper. Most of the white pine were two year old seedlings. Three-fourths of the buyers report a loss of less than five percent and some lost less than one percent. In the few cases where there was large loss there were evident reasons for it, such as excessive application of strong commercial fertilizer or the drying out of the seedlings by protracted drought before they had established new roots. In no single case was failure reported, which is surprising as well as gratifying considering the newness of the undertaking and the lack of experience in such planting by practically all concerned. It seems reasonable to anticipate results fully as satisfactory during the coming spring. Most cases of considerable loss were caused by dry, hot weather parching the plants in June and July; hence it is urged that the plants be secured and set a little earlier than was done last year.

KINDS OF TREES TO PLANT IN VERMONT.

The *white pine,* either in pure plantation or mixed with hard woods such as the hard maple and white ash, is *the most promising tree for general planting* in Vermont. Its value has been demonstrated beyond question and it may safely be used on any scale desired, large or small, if soil conditions are suitable. Of the other coniferous trees, the *red pine, Scotch pine, Norway spruce, European larch,* and *"white cedar"* (arbor vitae) deserve attention. The peculiar value of the *locust* for growing fence posts is discussed at the foot of this page. These will be offered by the State Nursery as soon and as far as practicable, and it is hoped trial will be made of them. In general, trial of kinds other than the white pine should, however, be made on a relatively small scale. The white pine seems suited to a wide range of Vermont soils. It will grow well on the leanest and rockiest of worn-out pastures, and on any land where spruce and maple will thrive. It is not suited to low wet land. The Scotch and red pines may be planted anywhere that the white pine will grow. They differ from the latter in that they make a somewhat faster growth for the first few years, especially if on very light soil. If one wishes to secure the quickest covering of such soil with valuable trees the Scotch pine is to be recommended, though it is doubtful whether the matured crop will be as valuable for lumber as the white pine. The red pine is a native tree, often called Norway pine, found growing at its best on rather dry gravelly loam and for such soil is quite as valuable a timber tree as the white pine. The Norway spruce is preferable to our native spruces and is adapted to similar soils, i. e., cool and fairly strong gravelly or clay loam. The same may be said of the European larch in comparison with our native larch. That is to say, if a man wishes to try larch or tamarack he should choose the European larch, which will probably grow well on any good soil of fair moisture, but is not adapted to dry sandy soil. No adequate trial in the planting of our native white cedar or arbor vitae has as yet been made. Where attempted, therefore, it should be in an experimental way and only on such soils as are known to favor it in the natural state. The common locust has a peculiar value. As explained in previous publications it is the most promising tree to plant for growing stakes and fence posts. It can be secured so quickly and cheaply from the seed that a trial plantation costs but little. It will grow in any soil that is not wet and is especially suited to waste ridges. The trees will reach a size suitable for posts in from 12 to 25 years.

and when cut reproduce themselves by sprouting from the root. The only serious question is as to possible damage from an insect, the locust borer. A small plantation of locusts to furnish posts is therefore well worthy of trial by anyone attempting forestry planting.

SEEDLINGS, ETC., FOR SALE[1]

The State Nursery, in compliance with the law, offers the following forest tree seedlings for sale in the spring of 1908, and will list orders as received so long as the supply lasts. These offerings are restricted according to law for use in plantations to be made in this State. Since the supply of white pine ready for distribution from the State Nursery this spring is quite limited, it seems fairer to all parties to restrict the size of orders in the way outlined below. In all cases the prices quoted cover cost of packing but not of carriage. The goods will be forwarded with express charges to be collected on delivery unless other arrangements are made. For convenience the prices are quoted by the 1,000, but orders for any smaller amount will be filled at the same rate.

Persons desiring to secure any seeds or seedlings, either from the following lots, or from commercial nurserymen with our advice, should write as soon as convenient, indicating their plans and asking for order blanks. Cash should not be sent with such requests. *Address all such requests to State Nursery, Experiment Station, Burlington, Vt.*

Lot 1. White pine, nursery grown, three years old, transplanted in spring 1907, size four to six inches. This stock is in excellent condition for setting in permanent forest plantation this spring. Price per 1,000, $10. *No order for over 1,000 to be sent to one person will be accepted before April 1.* If stock is not all engaged for such small orders by that date, larger orders will then be filled.

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[1] If the following lists are compared with those of last year, (bulletin 127) it will be seen that the offerings of white pine are limited to higher priced stock. Pine seedlings must be at least two years old before they can safely be taken from the seed bed for distribution or planting. The two-year old seedlings offered at a low figure last year were received through the courtesy of the New York State Nursery. Since none will be available from that source this year no more such low priced stock can be offered by the State Nursery until 1909. Presumably some of the seedlings started in 1907 can be distributed advantageously then and the aim will be to have others following in sequence each year thereafter.

Lot 2. White pine, nursery grown, four years old, transplanted in spring of 1906, size five to seven inches. This stock is a little larger and has stronger root growth than lot one, since it has stood two years in the nursery row since transplanting. It is in excellent condition for permanent forest plantation. Price per 1,000, $12. *Same restriction as lot one as to size of order* and the same restriction will hold for any order including lots one and two in combination, i. e., not over 1,000 total of these two kinds will be booked for one address before April 1.

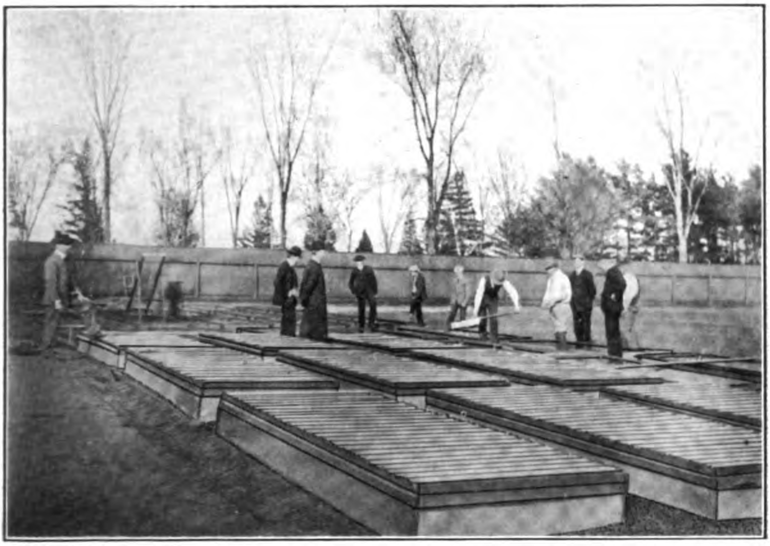
Lot 3. White pine, nursery grown, five years old, transplanted twice, size 10 to 12 inches, vigorous plants with strong roots suitable for planting where conditions are less favorable or where immediate results are desired. Price per 100, $2. *Not over 100 of these plants will be booked for any one party until after April 1.* Thereafter larger orders will be filled if the supply is not exhausted.

Lot 4. Common or black locust, one-year-old seedlings, two to three feet high, suitable for immediate use this spring in permanent plantations. Price per 1,000, $2.50.

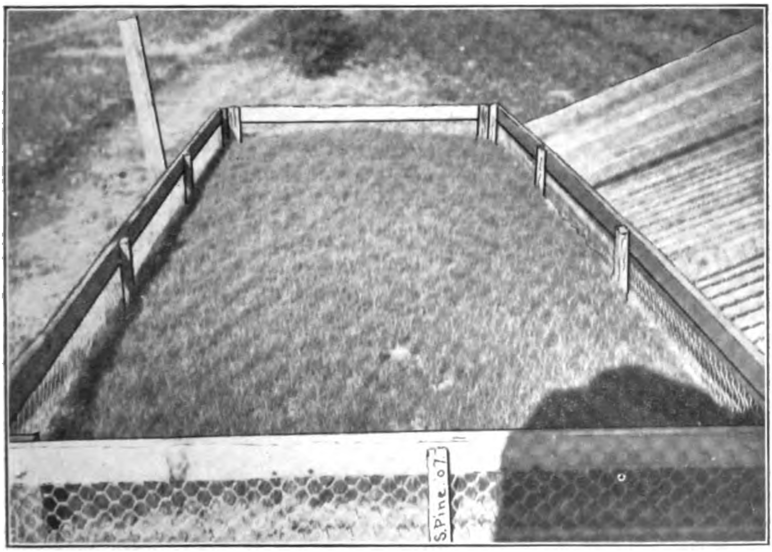
White pine seed. Native seed, collected in this vicinity in the autumn of 1907, sent by mail postpaid at the following prices:

One ounce	15 cents
Four ounces	50 cents
In lots of ten ounces or more to one party	10 cents per ounce

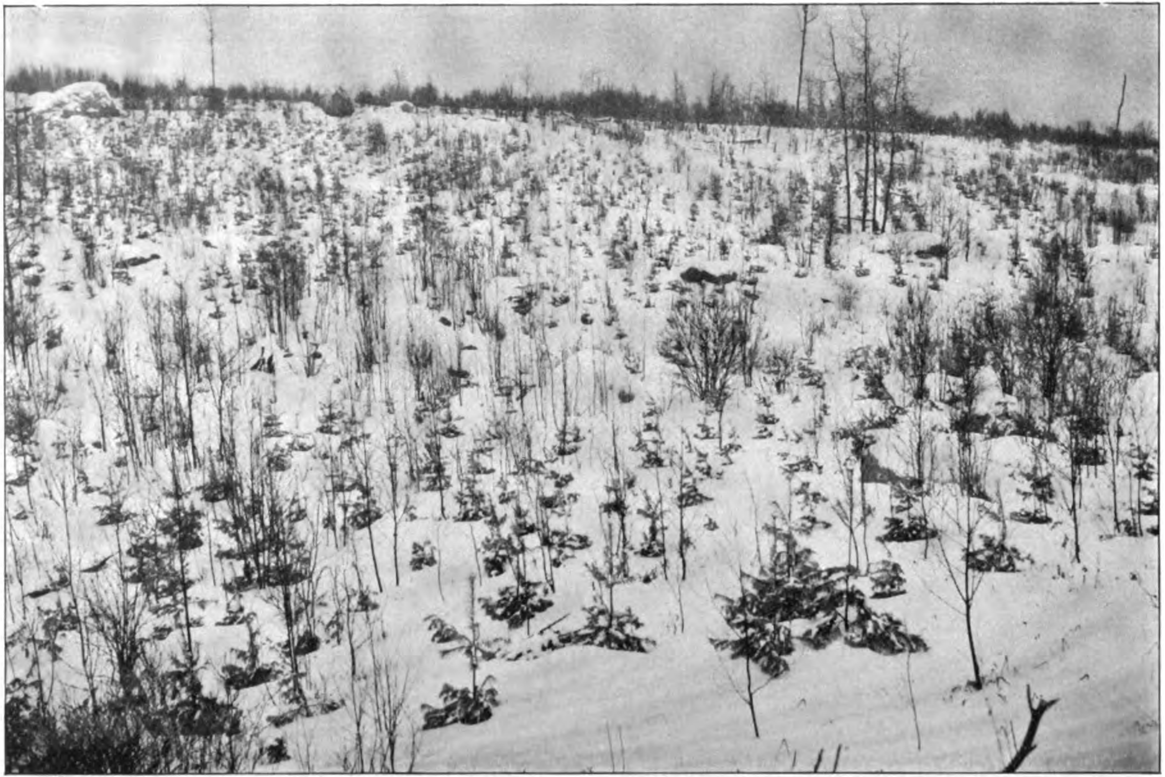
One ounce of seed properly handled should produce 1,000 or more seedlings. Ten ounces is sufficient to sow broadcast a bed 4 by 12 feet; or for a much larger area if put in drills. There is probably a sufficient supply at the State Nursery to meet all legitimate requests, but the right is reserved to decline large orders from our stock if necessary to fill larger numbers of small



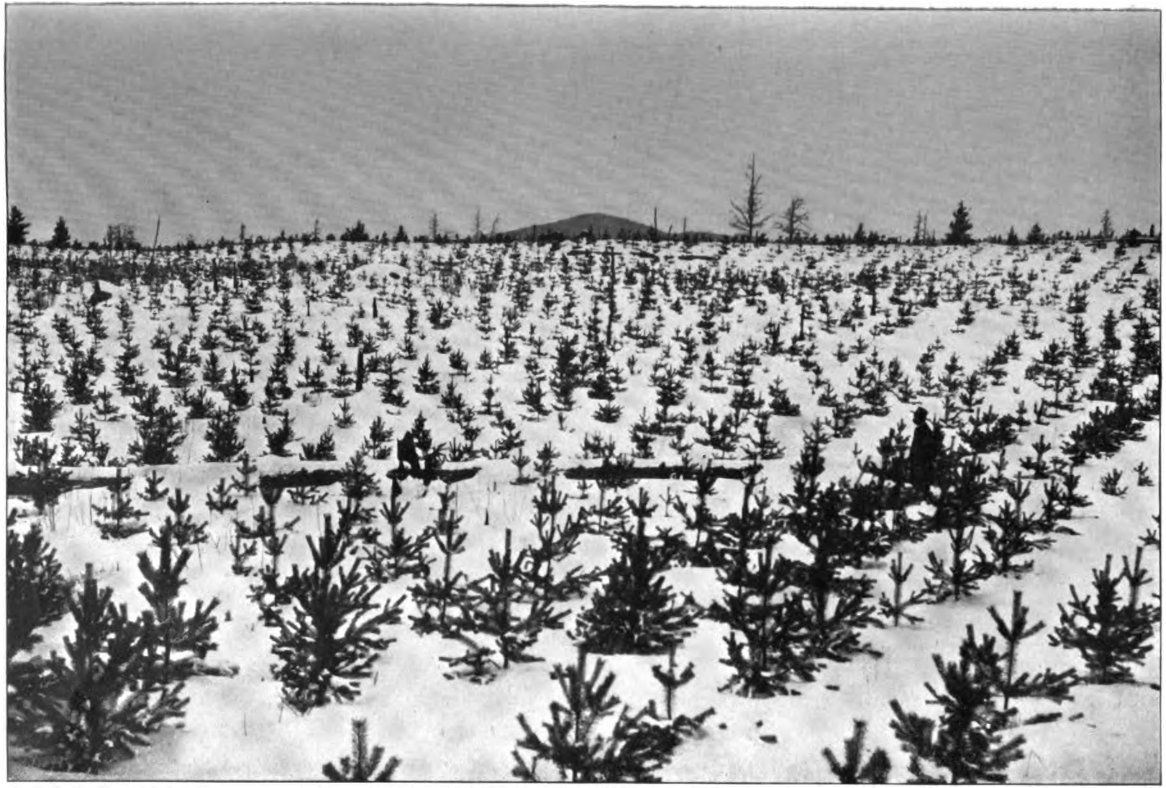
VERMONT STATE NURSERY. Making and sowing the seed beds, May, 1907. Each bed 4x12 ft.: surface slightly raised, seed broadcasted and a light covering of soil sifted over it. Beds in foreground completed; closely covered with building paper at sides and lath above until germination begins.



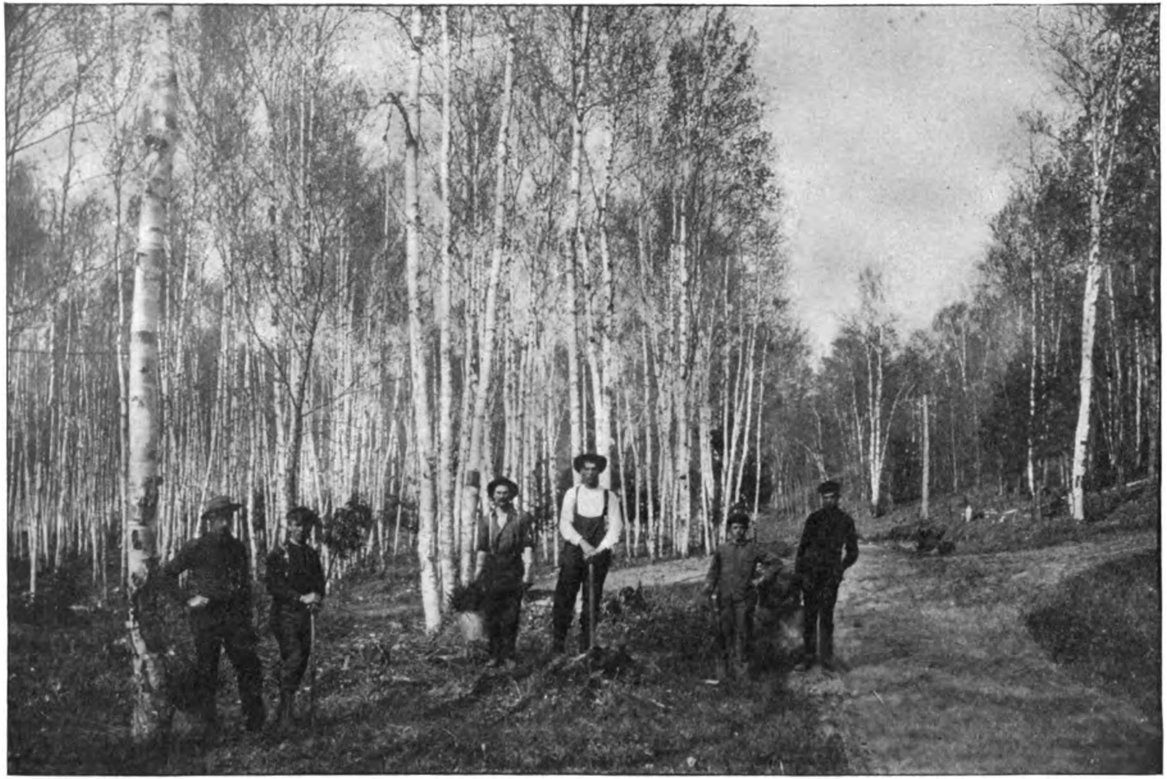
TEN THOUSAND SEEDLING PINES. As soon as germination begins the beds are uncovered, except that partial shade of lath is kept over them during bright weather the first summer. Wire screen to exclude birds. Seedlings must remain in the bed two years.



WHITE PINE PLANTATION. Waste land: natural growth of bird cherry and poplar underplanted with white pine. New York State land, Adirondack region. (This cut and the next two loaned by Col. W. F. Fox, N. Y. Supt. Forests).



SCOTCH PINE PLANTATION. Burned over land, planted in 1902, photographed in 1906. The Scotch pine makes a faster growth than the white pine for a few years, but the white pine will overtake it in the end. New York State land, Adirondack region.



Underplanting white birch with evergreen seedlings. On New York State lands near Saranac Lake. New York now owns 1,518,450 acres of state forest land, largely in the Adirondacks, and is this year contemplating the purchase of 1,000,000 acres more.

ones. In such cases aid will be afforded in securing such further seed as is desired from outside sources. (See general directions as to seed planting on page 21. Detailed direction will be sent to each purchaser of seed).

Native pine seedlings. The management of the State Nursery last spring collected and sold native white pine seedlings, three to four years old, size four to eight inches, for $3.00 per 1,000. The available supply near the nursery is so nearly exhausted that it cannot promise to collect many, if, indeed, it can any in 1908. It will, however, receive and enter requests for such and arrange to have these filled if found practicable. In this the nursery management will, however, merely act as agent to put collector and purchaser into communication. To this end it will be glad to learn the address of parties who can collect such native pine seedlings and the price at which they can be offered for sale. If any persons are found who care to undertake this work, such requests will be referred to them as received. As explained later (see page 21), nursery grown stock is generally better than native seedlings.

ASSISTANCE IN PLACING ORDERS WITH COMMERCIAL NURSERYMEN

The orders last spring exceeded the stock then available for distribution and the correspondence to date indicates a like condition for 1908. Arrangements are therefore contemplated by which such orders for stock of other kinds of seed or seedlings, or larger amounts than the State Nursery can supply, may readily be referred to commercial nurserymen. Prices on such goods will vary somewhat, according to the size of the order. It is not practicable to quote the exact prices further than to say that for white pine they will range from in the neighborhood of $4 per thousand for two-year-old seedlings (not transplanted) to $30 per thousand for the larger transplants. The trade catalogues will doubtless be issued before this bulletin is received by its readers and detailed advice will be furnished upon request thereafter. In this connection the State Nursery management will give those inquiring the benefit of its judgment as to the selection of stock and as to relative values offered. It will then put the prospective purchaser into direct communication with the commercial nurseryman. Further than this it can assume no responsibility.

ADVICE TO BUYERS AS TO CHOICE OF STOCK

Locusts. The State Nursery can probably meet all the requests made for locust seedlings—see lot 4—and the price of these is doubtless as low as plants of this size can be handled at any time in the future. Any one who desires to make a plantation of locusts may therefore well secure this stock.

White pine. The white pine seed is this year of excellent quality and low price. The pine seeds abundantly only once in three or four years, and 1907 was a good seed year. Those who wish to try planting seed will therefore have a better opportunity this spring (1908) than is likely to occur again for two or three years.

As already explained, none of the small seedlings (two years old) such as were offered last year, and will be next, are available at the State Nursery. If those are desired they must be secured from commercial nurserymen. All the stock listed was transplanted either one or two years ago and is, therefore, well suited for planting at once in permanent plantation.

ADVICE RELATIVE TO PLANTING TREES

A special circular containing concise and practical planting directions, prepared with the approval of the State Forestry Commissioner, will be sent to each purchaser. All that will be given here aims to help one in deciding as to the preliminary plans and the placing of the order.

WHERE TO PLANT

The most promising situations for forestry plantation in Vermont are where one can supplement the natural processes of reforestation, such as:

1. Recently cut-over woodland where the prospects are that imperfect tree covering would develop or where it would be of an inferior kind of trees.
2. Vacant spots in land naturally growing up to spruce or other valuable forest trees.
3. Old pastures now of low value because of weediness or inaccessibility.
4. Sandy or gravelly wastes, too barren for agricultural uses.
5. Steep hillsides where the soil is liable to wash badly.

Personal advice to individual planters will be given without charge so far as this can be done by correspondence. Where it seems desirable to have a personal visit from the consulting forester or other expert this will be arranged when practicable by the State Forestry Commissioner, providing the person requesting it will pay the travelling expenses.

Requests for such personal visits or for personal assistance in planting should be addressed to Arthur M. Vaughan, State Forestry Commissioner, Randolph, Vermont. In most cases the planter who has not had previous experience should be content the first year to make a small trial plantation unless he thus secures the advice of an experienced forester. He can hope to profit by his own experience and push the work more rapidly in subsequent years as dictated thereby.

TIME AND METHOD OF PLANTING

Season. Early spring is the best season for forest tree planting in Vermont. The work may begin as early as the ground can be worked and may with evergreens (pine, spruce, etc.) be continued as late as the middle of May or even the latter part of May. The earlier planting is safer however and is especially to be urged on dry soils which may suffer in early summer drought.

Distance. For general forest plantations a distance of 6 x 6 feet is recommended. This requires 1,210 trees per acre. Some advocate 5 x 5 feet (1,740 per acre) but the writers' experience favors the wider spacing. Others say that 7 x 7 (890 per acre) or even 8 x 8 feet apart (680 per acre) is close enough, and there are excellent plantations on the Billings farm at Woodstock where the trees are even farther apart. Where there is a natural sprout growth coming in to occupy part of the space and thus to help cover the soil, the artificially planted trees may be proportionately more remote. If for example white pine is destined to be the ultimate crop it is just as well to have one-half the stand of maple or similar trees which will serve as "fillers" for the first twenty years and so force the pines into taller, clearer growth. In such case a stand of pines 8 x 8 feet, or less than 700 to the acre, will certainly suffice.

Method. The roots of such seedlings as are recommended are small and the planting is a simple matter. It is best done by two men, one opening the holes with a grub hoe or spade, the other setting the plants by hand. Two men should set from eight hundred to fifteen hundred trees per day according to soil conditions.

Transplanting native seedlings. This is of course satisfactory and practicable for deciduous, or broad leaved trees, such as maple. It can also be done with good results in the case of the conifers or evergreens, such as pine, spruce, etc., where the seedlings are abundant. The only tree with which the writers have had much personal experience or about which they can learn from that of others in forest practice in Vermont is the white pine. It is possible in the spring to transplant young pine of any reasonable size. The pine seedling must be two years old before it is safely moved. Thereafter both the amount of work and the danger of loss increases rapidly with the size of the tree. The ideal age for transplanting pine is three to five years, when the seedlings are three to eight inches tall. Most people seem instinctively to seek larger trees but the smaller ones are preferable. Where such little native seedlings are abundant especially if in moist sandy loam apart from other growth, they may be collected cheaply and, if done in early spring and pains are taken to secure the roots unmutilated, they survive transplantation well. The roots come up best soon after the frost leaves the ground. Nursery grown plants are of course preferable as having a better root system and having received no check in their development, but unless these can be secured at a low price the use of native transplants is commended to such as can secure them cheaply and in abundance.

STARTING TREES FROM THE SEED

It is practicable for anyone, providing he cares to learn the methods and has time and an aptitude, to grow the seedlings of any of these forest trees direct from the seed. Two methods of seed sowing in the field have been advocated and tried more or less, namely, broadcasting and spot planting.

Broadcast sowing and spot planting. Broadcast sowing of the seed without previous preparation of the soil has often been tried with various kinds of trees, but rarely has it proved successful. The "spot planting" method entails opening or stirring up the soil in spots so as to make suitable seed beds at desired distances and planting from two to several seeds in each spot in the hope that at least one will survive. This has been proved practicable for some of the nut bearing and other broad-leaved or deciduous trees whose seedlings make vigorous growth during the first year or two. Locusts have been established in this way. Spot planting is preferable in general to broadcasting the seed, but both methods alike have as a rule been followed by disappointment and partial or complete failure, even with the stronger growing deciduous trees. White pine and other coniferous trees produce seedlings so weak and so slow of growth for several years that there is even less to encourage one to attempt field sowing of the seed. The large amount of expensive seed required is usually enough to render it impracticable. When to this is added the loss from birds and animals eating the seed, the irregularities in germination and the loss from the overcrowding of the weakling seedlings by more vigorous neighboring plants, the chances of a satisfactory outcome will usually be reduced to the vanishing point. In brief then, all having practical experience agree that the economical plan, at least with the smaller seeded coniferous trees, is to start the seedlings in garden beds and, later, to transplant them.

Seed beds. Believing that some at least of those who contemplate forestry planting will find it a matter of satisfaction and economy to grow their own seedlings the following general suggestions are given as to making and caring for such seed beds. Further and more detailed directions will be sent to anyone purchasing seeds. Home growing of tree seedlings in garden beds or rows is practicable. It requires an understanding of the methods suited to each kind, coupled usually with some practical experience, to insure full success. Locusts and other deciduous trees make strong growth from the start and so present relatively little difficulty. They can be planted in drills, and may be transplanted to the field when one year old.

Coniferous seeds such as pine, spruce, etc., need more care and the seedlings must remain in the seed bed two years before they are large and strong enough to be transplanted. The bed must be on well drained soil, preferably a sandy loam, free from weed seeds, in good tilth and carefully prepared. The seed may be drilled but is better broadcasted. In the latter case eight to twelve ounces of seed should be sown on a bed four by twelve feet. This seed should then be lightly covered with soil and the whole protected by a layer of leaves, straw or other litter or a close shade to hold moisture until germination begins. This requires two weeks or more according to temperature conditions. Partial shade must be kept over the seedlings during the first summer, either by brush or lath screens. If sparrows or other birds are numerous a netting to keep them away is also desirable. A protective covering of leaves or something similar is needed the first winter. Thereafter they require no unusual attention. The chief cause of failure is damping-off, a fungous disease which attacks the stems of the seedlings during the month immediately following their germination. Sprinkling the surface of the bed with hot sand is a partial preventive but the chief reliance must consist in keeping the surface of the beds as dry as practicable during this critical period. It is evident from what has been said that until one has had experience he should proceed on only a small scale in such nursery-bed work.

By attention to the more specific and detailed directions to be sent with the seed one may safely make such a trial of seed beds. Since white pine seed available this spring is of exceptionally good quality and low price it is believed that a considerable amount of it may wisely be used in this way.

LAWS AND REGULATIONS OF INTEREST TO TREE PLANTERS

The full text of the state laws and regulations relative to forestry is soon to be published as a special bulletin by the State Forestry Commissioner. This may be secured upon request addressed to Arthur M. Vaughan, Randolph, Vt. A brief summary of three matters of chief concern follows:

1. *The appointment and duty of the State Forestry Commissioner.* One member of the State Board of Agriculture is so designated by the Governor. His chief duties are to administer the fire laws, to formulate and administer regulations governing tax exemption for planted lands, and to issue forestry publications. The first selectman of each town is forest-fire warden; and the Forestry Commissioner may appoint fire-wardens for unorganized towns or gores. The duties of the Forestry Commissioner and fire-wardens relative to extinguishing forest fires are clearly defined, as is the liability of persons setting such fires. The Forestry Commissioner advises relative to forestry plantation, publishes bulletins concerning forestry matters, and formulates and administers regulations relative to tax exemption of planted lands.

2. *Regulations relative to tax exemption of land planted to forest trees.* All forest or waste lands replanted to trees in the manner prescribed by the State Forestry Commissioner may be exempt from taxation for a term of ten years thereafter. According to the rules recently promulgated such planted trees shall be

set as close as eight by eight feet and comprise a total of at least six hundred per acre. Such land must be maintained in good condition, must not be pastured, and must carry at least five hundred living planted trees per acre at the end of five years. The commissioner prescribes the species and the season of planting.

3. *The establishment and purpose of the State Nursery.* The sum of five hundred dollars annually for five years (1907-1911) is to be paid to the Experiment Station to be used in establishing and maintaining a State Nursery for the propagation of forest tree seedlings. These are to be furnished as far as practicable to owners of Vermont lands for forest planting in this State at as near as can be computed the actual cost of production.

UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 137

JULY, 1908

Abstract Twentieth Report, 1906-07

(Crops, Forestry, Stock Feeding, Dairy Husbandry)

CROPS.—Pages 228-235.

FORESTRY.—Pages 235-238.

STOCK FEEDING.—Pages 238-251.

DAIRY HUSBANDRY.—Pages 251-262.

INDEX.—Pages 263-264.

BURLINGTON:
FREE PRESS PRINTING CO.,
1908.

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☞Address all communications, not to individual officers, but to the Experiment Station, Burlington, Vt.

Director's office, chemical, horticultural and dairy laboratories are in Morrill Hall, at the head of Main street; botanical laboratories are at Williams Science Hall, University Place; veterinary laboratories at 499 Main street.

Experiment farm and buildings are on the Williston road, adjoining the University grounds on the east.

BULLETIN 137; ABSTRACT TWENTIETH ANNUAL REPORT, 1906-07
CROPS, FORESTRY, STOCK FEEDING, DAIRY HUSBANDRY

JOSEPH L. HILLS

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INTRODUCTION

Following the precedent established four years ago, abstracts of the twentieth annual report are presented in this bulletin and the preceding number in which the matters of more direct practical interest are briefed. Recipients of either bulletin desiring to receive the full report have but to ask, specifying by its number—twenty.

The twentieth report marked the close of as many years of station existence. Since preceding issues are mostly out of print, but frequently called for, it seemed both desirable and appropriate to gather therein brief resumés of such studies as possessed more than ephemeral interest. In the two abstracts presented are statements:

No. 136—Concerning plant diseases, weeds, horticulture, insects and insecticides.

No. 137—Concerning crops, stock feeding, and dairy husbandry.

The writer is responsible for the editing of the briefed matter. The articles to which authors' names are attached are condensed from the new matter appearing in the twentieth report. The material as printed in the report which is condensed from previous publications shows authors' names and gives references to the original publications. Owing to exigencies of space, only the barest outlines are given.

CROPS

The proper time to harvest corn in Vermont. Several different trials of this matter have been made. In 1893 Sanford and Red Cob corns were cut August 13, 29, September 13, 28, and (Red Cob) November 17, weighed, sampled and analyzed. The practical outcome may be stated as follows: (1) the corn plant increases its weight and value as it grows older, but (2) the carbohydrates increase so much faster than the protein that its quality decreases as it grows older; yet (3) the great increase in weight far overbalances the quality loss. (4) Green corn fodder usually weighs the most just as the kernel begins to glaze; but (5) it does not then contain as much dry matter as when fully glazed and mature; hence (6) varieties that will mature should stand till ripened, while those which do not should stand as long as they are safe from frost. (7) The increase in dry matter after the kernel has begun to glaze is mainly starch and kindred nutrients; hence (8) it may not always pay to run frost risks for the sake of the increased weight, particularly if the crop is to be stooked. If ensiled, the crop can be grown closer to frost without danger.

In 1900 and 1901 Sanford, Red Cob, Leaming and a Virginia dent were planted. Sanford corn is a relatively small flint corn, largely grown and favorably known throughout northern New England; Red Cob, a larger variety which occasionally matures at Burlington; Leaming, a yet larger variety, popular in southern New England, characterized by excessive leaf growth; the Virginia corn (variety unknown), a large, impressive-looking dent corn.

The larger corns produced from 50 to 70% more gross weight than did the Sanford, but averaged only 10% more dry matter, and that was less mature. The several crops were ensiled and fed. When the cows were changed from Sanford silage to that made from the larger growths, shrinkage of milk flow ensued unless an increased amount of silage was fed. The Sanford silage was a shade richer in protein and much richer in carbohydrates than that made from the larger growths, doubtless due to its greater maturity.

The large corns look impressive, but they yield but little or no more actual food matter than do some smaller varieties. The farmer has, moreover, to harvest and house large tonnages of water which may generally be procured cheaper in other ways.

The best method of harvesting corn. For three years this query was put to the cows:

(1) 1891. Three fresh cows were fed 16 weeks on either silage or corn fodder from the same piece. Equivalent amounts of dry mat-

ter being fed, the gains from feeding silage were 9% milk, 6% solids, 4% fat. More product was obtained from a pound of dry matter when ensiled 6 times in 9. The silage was less laborious to feed.

(2) 1892. Twelve cows were fed 20 weeks with hay, grain and the corn plant either (a) ensiled, (b) stooked, (c) husked, the stover ensiled or (d) husked, and the stover stooked, the ears being ground and fed with the stover in (c) and (d). Every cow was fed the corn plant harvested in each of these ways for at least four weeks and was fed it when harvested in some one of these ways twice for four weeks during the first and the last feeding periods of the season. Thus, for example, 3 cows were fed silage in November and March, were fed corn stover plus the proper amount of ground ears in December, were fed stover silage plus ears in January, and were fed corn stover 82 pounds for each 100 pounds produced by silage. Since opportunity to record her verdict as to the economy of the four harvesting processes.

(3) 1894. Fourteen cows were to be fed in the same manner as above outlined under (2); but owing to the unpalatable dry forage harvested in that extremely droughty year the cows would not eat enough of it to maintain their flesh; hence 6 cows were fed (a) silage and (c) stover silage (with ground ears).

The combined and condensed deductions drawn from (2) and (3) may be stated as follows:

1. From 18 to 20% dry matter was lost by each method of harvest.
2. The losses fell most heavily on the nitrogen-free extract and ether extract, but slightly on the ash and fiber. The protein losses approximated 10%.
3. The stooked fodder losses increased as the winter progressed.
4. It cost less to put dry matter in the manger by way of the silo than by way of the stook. The time and money spent in husking and grinding the ears (16 cents per bushel) was wasted, since better results were attained when the ears were left on the stalks.
5. The silages were better relished than were the fodders and the cows did better on them.
6. In 1892 the stover silage ration produced at the rate of 82 pounds of milk, the corn fodder ration at the rate of 92 pounds, and the corn fodder (ears and all) in February. Hence each cow had her the quality was unaffected the proportions were the same as regard to the yield of butter. In 1893 there were 91 or 92 pounds of milk and butter produced by a given amount of dry matter in the stover

silage and meal ration, as compared to 100 pounds produced by the same amount of dry matter in the whole silage ration.

7. The whole silage lasted longest each year. An acre of whole silage equalled in milk producing power 1¼ acres ('92), and 1 1-10 ('94) of stover silage and ears, 1 1-12 acres of corn fodder, 1¼ acres of corn stover and ears.

The effect of frost on corn for silage. Twenty-one cows were fed experimentally for nearly six months on silages made (1) from immature corn, (2) from immature corn very slightly frost touched, (3) from a mature corn very slight frost touched, and (4) from a mature corn hard frosted. Not every cow was fed each of these silages; but they all contributed to the solution of the problem as to the effect of frost on corn for silage. The results of the trials were held to warrant the statements that: (1) "More dry matter was eaten when the mature silage was fed; that (2) the quality of the milk made when the silage from the frozen corn was fed was depressed slightly; that (3) the total solid and fat yields were slightly depressed when the ration containing the frozen corn silage was fed; and that (4) the products per unit of consumption were depressed when the more mature silages were fed, owing to the greater consumption but smaller production." In these trials the effect of frosting corn, and yet more of freezing it, appears very slightly to have been to depress its feeding value. In view, however, of the fact that from 6 to 15% more dry matter was harvested as a result of the two weeks' longer crop growth, the slight depression resulting from the feeding of silage from frozen corn is a negligible quantity. No ill result on the butter product was observed. Silage made from frozen corn seems to keep well in a good silo. It would appear that the testimony of this trial favors the running of frost risks to gain a greater maturation.

Large and small stooks of corn. A ton of frosted corn fodder put up in two large stooks, lost 14% dry matter from October 24 to December 10, as compared with 15% loss from a ton put up in 6 to 8 stooks.

Losses of food matter in stooking corn. Immature (in the silk) corn, stooked August 9, standing exposed four months as do ordinary stooks, lost 29% dry matter, 11% ash, 16% crude fiber, 21% protein, 38% nitrogen-free extract, 67% ether extract. The outcome is commended to the study of those who believe that there is nothing but water lost from stooked corn.

Fowl meadow grass. This is the best native grass for use on wet soils. It now occupies large areas of flowed intervals and its value for such situations has been long known. Closely resembling red top it is softer, has a more slender habit and lighter color. It may be cut at any time from July to October at will.

Several years' trials indicate the correctness of the following statements: Seed of good quality is produced abundantly, yielding 6 to 7 bushels per acre, and the threshed hay is almost as palatable as that cut earlier. Growth from seed is easily obtained, but the grass requires two or three years to fully establish itself.

The yields from natural overflowed interval meadows are 1¼-2½ tons per acre, exceeding those on adjacent timothy pieces. Timothy tends to decrease in quantity and deteriorate in quality, owing to the displacement of the timothy by the sedges. The yield increases up to seeding time, and since the quality remains good it may be cut late. The hay is of good quality and as well relished as is upland hay.

For sowing on wet soils a mixture may include variable proportions of red-top, fowl meadow, timothy and alsike clover. If the soil is favorable, fowl meadow will form an increasing proportion of the crop until in 3 or 4 years it will entirely replace the other grasses and thereafter persists. Sowing in midsummer without grain or other nurse crop is advised.

Alfalfa in Vermont. Alfalfa is a plant of the clover family, larger, longer lived and in many ways superior to common clovers. It is richer in digestible protein and a better soil and manure pile enricher than is any other economic plant. It is well adapted for use as hay, silage, and soiling. It has been of late increasingly grown in northern latitudes, though little success has been met in New England outside of Vermont. In Quebec, Ontario and northern and central New York it has succeeded at several points.

Fifty-six trials are summarized, with permanent successes 12, temporary successes 10, success at outset 8, seeming success 5, questionable 7, failure 14. Two-thirds of the successes attained with this crop were located within the Champlain valley. Its preeminence in alfalfa growing seems to be due to the character of the farming in that section and to the nature of its soil. Failures may generally be ascribed to one or more of several unfavorable soil or weather conditions, to weeds, to disease, or to seed which either is inferior or from an unsuitable source. Suggestions are offered as to means of combatting these difficulties and the collection of home grown seed is commended.

Alfalfa culture in Grand Isle County. Alfalfa succeeds admirably in Grand Isle. The soil and climatic conditions favor, particularly the good natural surface drainage of a basic soil rich in lime and potash. It was first grown in 1889 by Mr. S. G. Macomber, and is now widely used. Everyone who has tried it on suitable soil has had fair success, and pronounces it profitable, usually deeming it the most profitable crop he can grow. It is succeeding best on gently sloping gravelly or slaty clay loams with good natural underdrainage. Winter killing is attributed to standing water or to the formation of a surface sheet of ice.

The methods of culture employed are briefly: Thorough preparation of soil; freedom from quack (witch) grass; seeding with oats or barley in spring as early as possible, using 20 pounds seed; no further treatment the first year save grain harvest; cutting thrice yearly in succeeding years; a light annual top dressing with commercial fertilizer; no harrowing, discing, etc. Quack grass and dodder have been the most troublesome weeds. The crop is hayed, being but little more difficult to cure than red clover. In only one case has a full stand continued five years. No seed or soil inoculation is practiced or seems needed. The crop is held to be so desirable that, though winter killed the third year, yet would it be deemed profitable.

A poisonous plant, the common horse tail (*Equisetum arvense*). This plant is seriously poisonous when fed in hay to horses. Its nature is described, the extent of the trouble indicated, symptoms shown, the affecting conditions and the extent of the poisoning process are discussed and treatment suggested. It is a common native plant, thriving best in sandy or gravelly soils which are moist a part of the season or with a relatively high water table. It is quite apt to grow in sandy, overflowed interval meadows, mixed with wild grasses and "polypod brakes." No evidence is at hand indicating that cows are affected; sheep appear to be less quickly or easily injured; but horses are commonly poisoned.

Feeding experiments were made during two winters, using five horses. All were killed by the feeding. Careful records were made of symptoms and of post-mortem results. The essential symptoms are: swaying and staggering, inability to stand, rigidity and convulsions of the muscles. Young animals succumb more readily than older ones; grain-fed animals resist the poison longer than do those not grained. The plant, despite its toxic qualities, is eagerly eaten by horses. There is no evidence that when eaten in the green state it is poisonous. Treatment: discard the poisonous hay; purge and follow with nux vomica.

Miscellaneous fodder crops. Many different forage crops were grown experimentally in the first decade of the station's work. The general results may be summarized as follows:

LEGUMES. *Clovers* (red, mammoth red, alsike), averaged 1½ to 2 tons hay to the acre, white clover less than a ton to the acre. Attempts were made during several seasons to secure a growth by sowing crimson clover at different times during the summer and early fall, but all were unsuccessful. Only under exceptional circumstances can it be carried from fall to spring. As an annual spring sown crop it does well (8 tons green fodder).

Soy beans. Three varieties grew well, making from 2 to nearly 12 tons of green forage and from ⅔ to 3 tons of dry matter. Again it yielded 5 tons green fodder, 1.25 tons dry matter. This crop is well relished, green, ensiled, or hayed. The green and black varieties are the best annually cultivated leguminous crops tried here.

Flat pea (*Lathyrus sylvestris*). This perennial made a spindling growth in 1894, a waist high, tangled mass in 1895 and 1896 (6¾ tons of green fodder, 2 tons hay, ½ ton protein per acre in 1895), and was largely killed out by witch grass in 1897. The crop of 1896 was ensiled, but not relished. The green fodder is eaten reluctantly.

Cow peas. Thirty-seven farmers made 30 reports on crops of medium to good growth as follows: Failures 12, indeterminate 6, possibly desirable 5, inferior to corn 11. The cow pea is not a plant likely to prove of benefit so far north as Vermont. It presents no advantages over soy beans, and yields less dry matter and protein. The latter are harvested with greater ease and are well relished.

Oats and peas. Nineteen tons green forage, 5 tons dry matter; a well-known and too little grown combination.

Peas, oats and rape. "Good growth, more than half * * * rape."

Vetches with oats. 7¼-10½ tons green forage, 2-3 tons dry matter. "Experience for several years does not lead us to consider them equal to peas and oats."

Villous vetch (with soy bean; with horse bean; with oats and rape). "Fair growths, mostly of vetch save in the third combination, which grew 3½ tons green forage."

Sweet clover. Very welcome to bees, refused by cattle.

Seradella. 2.5 tons green forage per acre; a small plant of low growth but dense foliage; not readily eaten at the outset; fairly rich in protein; not a promising forage crop.

Horse beans. "Not successful, growth small."

MILLETS. *Japanese millets.* 1893, "Did not do well; they were planted in a particularly weedy spot and had a hard struggle." 1895: yielded from 8.5 to 19 tons of green fodder and from 2.5 to 5.25 tons of dry matter. Rapid growers; an impressive showing; protein content very low; better results by broadcasting than by drilling; readily eaten.

Hungarian. Grew less luxuriently than Japanese millets; richer in protein.

MISCELLANY. *Green barley*, sown July 31, was fed from October 17 until late November, being green and well relished until Thanksgiving. It yielded 1½ tons of hay per acre.

Winter rye. Sown in September, cut in mid-May with the heads just beginning to show; carried 12.75% dry matter and 2.2% protein, being thus richer in this nutrient than is clover. Eaten with relish. Ten days later, when beginning to blossom, the stalks became tough and it was rejected. Neither did it fare better as silage.

Kafir corns are non- saccharin sorghums largely grown in semi-arid regions because of their drought-resisting qualities. They grew 4¼ and 4 tons of dry fodder to the acre, formed seed heads but did not mature seed. The fodder was well relished, and the dry matter was closely similar in composition to that of corn. "There seems no good reason for growing kafir corn in a climate where Indian corn can be raised successfully."

Prickly comfrey. First season cut three times; yielded about 1½ tons hay per acre; second season cut four times; yielded at the rate of 4¼ tons hay per acre. Readily eaten but difficult to harvest.

Japanese buckwheat was much in the public eye in the late eighties. A crop grown in 1888 yielded at the rate of 2 tons of hay per acre. Cows did not relish it, but horses ate it readily. A crop grown in 1889 yielded at the rate of 41 bushels per acre. Sown May 8, it yielded over 1⅜ tons dry matter per acre in 11 weeks when in full blossom and 2 tons when ripe a month later.

White mustard is remarkably rich in nitrogen. It is used by some for green manuring, on the ground that it helps to keep down the weeds, improves the soil and tends to prevent soil washing. It is not eaten by cattle to any extent.

Japanese radish. A large growth of tops, but almost no roots. Cattle would eat neither.

Sunflower. "Heads produced 1.5 tons of dry matter, including over 600 pounds fat."

Silage corn. Sixteen varieties, mostly dents, sown May 30, cut October 1, yielded at the rate of 6 to 11 tons of immature green forage per acre.

MAPLE INVESTIGATIONS*

*Bulletins 26, 103 and 105 are in ample quantities and will be sent on request.

THE VERMONT STATE NURSERY FOR FOREST TREE SEEDLINGS[1]

L. R. JONES

THE DISTRIBUTION OF SEEDLINGS IN 1907

An immediate effect of the passage of the act establishing a Forest Nursery was a stimulation of popular interest in the possibilities of forestry plantation. Requests were received for far more seedlings than were available for distribution; hence late requests were entirely declined and large orders filled only in part. From various sources white pine and black locust seedlings were offered for sale in limited amounts as listed on page 46 of bulletin 127, and shipped to twenty parties, five each in Windsor and Orange Counties, three in Rutland, two in Lamoille, and one each in Caledonia, Windham, Chittenden, Addison, and Washington Counties. These were accompanied by directions for unpacking, for setting, and for caring for the seedlings in the nursery row, (soil, beds, spacing, planting, subsequent care and a brief statement as to permanent planting. Personal visitation was made to several of the plantations in the fall and their condition noted. In order to secure data as to success or failure inquiries were addressed to each purchaser as follows:

I. Did you receive the shipment promptly and in good condition?

II. Did you plant promptly, or was there delay? If so how long, and in what way were the trees stored meanwhile?

III. Did you plant any in nursery row (i. e. in garden or other beds)?

IV. In what condition are these plants now? (Sept. '07).

V. What disposition shall you make of these transplants next spring?

VI. Did you place any in permanent plantation?

VII. In what condition are these plants? State percentage of loss.

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[1] The establishment of this enterprise was discussed in bulletin 127 (April, 1907), wherein it was stated that the last General Assembly passed an act providing that, for a term of five years, five hundred dollars be paid annually to the station to aid in the establishment and maintenance of a nursery for the propagation and distribution at cost of forest tree seedlings; the station to provide at its own expense necessary land and expert supervision.

VIII. Do you plan to fill vacancies where seedlings have died?
IX. Are you planning to plant in 1908?
X. Have you suggestions to make, based on experience this year?

ANSWERS RELATING TO 2 YEAR OLD WHITE PINE SEEDLINGS

I. The goods were received promptly and in good condition.

II. Two-thirds of the recipients planted within 24 hours of arrival and most of the others within a week. In one case they were kept two weeks and in another nearly four before planting, being trenched or "heeled in." While this delay is undesirable it was not seriously injurious. A 10% loss, mostly attributable to delay in planting, was reported in the second case.

III. The directions recommended placing 2 year seedlings in the nursery row for a year or more. Most buyers thus placed them; some placed part thus and the balance in the field; a few put all in the field. Where set in the nursery they were planted in rows four to six inches apart, and given clean culture.

IV. Considering the lack of experience and the unusually trying midsummer heat, the results were gratifying. Two-thirds reported a loss of less than five percent, and with most others the loss did not exceed ten percent. Where it exceeded this there was generally evident reason for it as; a dry southern slope and unusually parching heat killed many plants before they had established themselves; a heavy application of commercial fertilizer upon the beds, etc.

V. Those who set the seedlings in nursery are about equally divided in their plans. About one-half of the plants are to be carried another year in the nursery row and about one-half are to be transplanted to the field in 1908.

VI. Some set a portion and a few set all, mostly in permanent plantation, 6x6. The grub hoe or spade was used and no difficulty experienced. The situations planted included worn out hillside pastures, recently cut woodland, or sprout land, and open places in young forest growth.

VII. In spite of the small size of the seedlings and the lack of experience in planting, three-fourths of those who set the seedlings in permanent plantations report good success. In general 90 percent of the seedlings survived. Two expect to collect native stock for seedlings thus treated lived. In one case the majority were lost, due to planting on a dry hillside followed by a severe drought; in another 20 percent were lost because the planted area was in a pasture and the cattle stepped on the plants.

VIII. Practically all who started permanent plantations propose to fill out vacancies where seedlings have perished.

IX. Three-fourths of those ordering in 1907 propose to place another order in 1908.

X. Several helpful suggestions were made: (1) that the directions issued urge prompt planting; (2) that transplanting be done as early as practicable; (3) that cattle and other stock be excluded; (4) that attention be called to the fact that transplanting native seedlings can be practiced cheaply and successfully where they occur plentifully; (5) that publicity be given to State Nursery offerings and to the desirability of reforesting waste lands.

The outcome meets all reasonable expectation. Requests were far in excess of supply and indicate that the public is ready for the work. Purchasers succeeded well, showing that it is practicable thus to handle seedlings. Those who made a beginning propose in most cases to continue, showing that the movement may be expected to gain in momentum.

LOCUST SEEDLINGS

Some 5,000 locust seedlings were sold. These are recommended for small trial plantations, since the question of local adaptation and of injury to the borer remain to be answered by experience. They were reported in good condition at the end of the summer, making rapid growth, with but a small percentage of loss, save in one case where many were killed by a severe drought soon after planting. There is no reason to doubt the general practicability of handling locust seedlings.

Statements concerning offerings are made yearly in the spring bulletin.

COLLECTING WHITE PINE SEED

White pine is a native of America only. It has been cultivated in Europe as a forest tree for many years, chiefly in Germany, and much of the seed offered even in the American market comes from Germany. There is reason to believe, however, that the highest success both in raising the seedlings and in the subsequent growth of the plants is conditioned upon the use of freshly collected seed from our native trees. There is experimental data to show that with some other trees, at least, seed from a more southern source or strain, or from a milder climate, does not produce as hardy stock as does the native or that from a northern locality. While this has not been experimentally established for the white pine, it is at least the reasonable course in this State Nursery work to use native seed so far as obtainable. Appreciating the fact that 1907 was to be a "seed year" for the white pine in this section, a circular was issued through the press of the State about the first of September calling attention to the desirability of collection of seed. Following this announcement a number of parties undertook to collect pine seed. One man collected fifty bushels of cones, and extracted therefrom some fifty pounds of seed. Several others gathered smaller amounts. Employees of the State Nursery collected on the University farm fifty bushels of cones. It will be one aim in this movement to encourage systematic collection of pine seed, with the further hope that some may be led to grow the seedlings. When enough have learned to do this, the State Nursery will become unnecessary.

STOCK FEEDING

The relative feeding values of two rations of equal balance. What differences in production may be expected when rations are fed containing the same amounts of digestible nutrients yet made up largely of different materials?

This matter was under survey during three years, 34 cows being used. The first two years the rations were of medium balance, being rarely wider than 1:7 or narrower than 1:6. The third year two sets of rations were used, one with a nutritive ratio approximating 1:6, the other, 1:8.9.

The outcome of three years' trials seems to indicate that equivalent production is not of necessity to be expected when cows eat equivalent amounts of digestible nutrients derived from diverse sources.

The relative feeding values of "medium" and "wide" rations. This matter was under survey for three seasons. The results when grain was fed in equivalent amounts were essentially as follows: From 6 to 11% increase in production followed the substitution of a cottonseed-linseed ration in place of a corn and bran ration, the nutritive ratios averaging 1:1.6 and 1:1.10. The next year the producing power of a unit of dry matter was found to be 7% greater when the narrower ration was fed, a cottonseed-linseed ration being fed against Quaker oat ration, with nutritive ratios averaging 1:5.8 and 1:9. The third year, a repetition of the former year's trial, showed a 2% gain per unit of dry matter on the narrower ration, nutritive ratios being 1:5.3 and 1:5.7. The quality of the milk remained unchanged in all cases.

When the balance of the ration was varied by changing the amount of grain fed, the following results were obtained: When 3 pounds bran, 2 pounds corn meal, 1½ pound each of cottonseed and linseed meals were fed daily as compared with 2 pounds of bran and 1 pound of corn meal daily, the rations showing nutritive ratios as 1:5.9 and 1:11.8 "production paralleled feeding. Lessening or increasing the dry matter one-fourth respectively lowered or bettered production one-fourth. The milk was slightly poorer on the wider and scantier fed ration."

The second year's trial when five cows were used, fed 8 pounds of Buffalo gluten food against 2 pounds corn meal, 1 pound bran (nutritive ratios 1:5.5 and 1:9.5), a unit of dry matter contained in the "medium" ration made 5% more milk than did one in the wide ration. Less but better milk seems to have been produced by the scant ration.

In an earlier trial, using five cows during a winter's feeding, no relationship whatsoever was traced between changing nutritive ratios of the several rations and the products made coincident with such changes; that is to say an attempt was made to trace connection between increased protein eaten and gain in milk flow, but without success. Furthermore no connection could be traced between varying protein contents of the food and the casein content of the milk.

Feeding tests with corn by-products. The summarized statement as to several trials with over 60 cows, some loosely, some closely controlled, reads as follows:

1. *Cream gluten meal*, *King gluten meal* and *Buffalo gluten feed* were found to possess considerably greater feeding values pound for pound than has equal parts of corn meal and bran, while corn germ feed has about the same feeding value, and Chicago maize feed has little greater feeding value than has the corn meal and bran.

2. The feeding of these by-products seems to produce a slightly richer milk, one in which the fat is disproportionately increased. The change, however, is not sufficiently marked to be of practical importance.

Corn oil cake was fed to 6 cows as against corn and bran for 20 weeks. A pound of dry matter in the former produced a twelfth more yield than did a similar amount in the latter ration.

Germ oil meal was fed to 8 cows for 6½ months as compared with cottonseed and linseed meals and with bran and oats. The germ oil meal ration made 3% greater product than did the cottonseed-linseed and 6% more than did the ground oats ration. The quality of the milk remained unaltered. It carried much less digestible protein than did the cottonseed-linseed and one-fourth more than did the ground oats ration. The greater manurial value of the cottonseed-linseed ration gave it a slight advantage over its competitor. The germ oil meal ration proved superior to that containing ground oats to the extent of 1.50 cents daily for each cow.

Two lots of a gluten meal of the same make, one carrying 29, the other 36% protein, were fed in competition to four cows for nearly four months to determine whether the cow would confirm the chemist's findings and yield less when fed the poorer meal. She did not, since as much and as good milk was made on the one ration as on the other. The cows doubtless got enough to eat in either case.

The feeding value of distillers' dried grains. These were fed in two different seasons. Fed to six cows for 20 weeks against a mixture of equal parts by weight of corn meal and bran, it produced per pound of dry matter an eighth more milk and a sixth more fat. It was fed to 16 cows for nearly six months. Fed clear and undiluted it made 4% less milk of unchanged quality than did a ration one-third of which was wheat bran and two-thirds distillers' grains. The latter made a financial gain of three-quarters of a cent daily per cow over the clear grains ration. The cows rarely ate more than 7 pounds in 8 of the clear grains. Compared with brewers' dried grains it made 5 to 8% more milk and butter, but, owing to the low cost of the brewers' grains, the latter proved the more economical. Distillers' dried grains and cottonseed-linseed meals proved equally efficient, but the latter was the more economical ration. Distillers' dried rye grains made less milk and butter than did the alcohol grains, a result which was foreshadowed by their analyses.

The feeding value of brewers' dried grains. This material was fed during two seasons, the first year to a single cow as compared with cottonseed-linseed meals; the second year to five cows making the same comparison and to six cows in comparison with distillers' dried grains. When compared with cottonseed-linseed meals they proved essentially equivalent, but the low price then placed for the brewers' grains made them economically preferable to the cottonseed-linseed meals. The distillers' grains as compared with brewers' by-products made 5% more milk and butter. The latter were economically the better ration.

The feeding value of malt sprouts. Six cows were fed malt sprouts for six months compared with cottonseed-linseed meals and with corn and oats. They were not relished. Some cows refused to eat them dry or soaked. When fed against cottonseed and linseed meals, dry matter consumption and milk yields dropped a tenth. When fed in comparison with ground oats, dry matter consumption dropped 9% and milk yields 4%. The quality of the milk was unchanged. The production to a unit of dry matter was the same on the sprouts ration as on the cottonseed-linseed one and 5% greater than on the oats ration. The cottonseed-linseed ration proved more economical than did the malt sprouts, the daily net gain per cow being 1.93 cents, half in extra butter and half in extra skimmilk and manurial constituents. The extreme high cost of oats made the financial showing unfavorable to that ration.

The feeding value of buckwheat middlings. Ten cows were used during two seasons.

Quantity. When 4 pounds buckwheat middlings replaced 1 pound corn meal and 1½ pounds each of cottonseed and linseed meals, production dropped about 3%; when it replaced corn meal, the production gained about 4%. The results the second year were more pronounced. A buckwheat middlings ration seemed fully equal to a cottonseed-linseed ration and carried a shade more digestible protein. It made from 8 to 11% greater product than did the ration of half corn and half bran.

Quality. Whenever fed, the quality of the milk was improved nearly 0.20%. This disproportionate increase in the fat content was observed both years. Buckwheat middlings fed in considerable quantities tends slightly to increase the fat percentage of milk.

Financial considerations. Buckwheat middlings made cheaper milk and butter than did the cottonseed-linseed or the corn and bran rations. The quality of the butter seemed somewhat impaired when they were fed in large quantities. Buckwheat middlings are highly variable in composition, as more or less of the hulls are included.

The feeding value of India wheat meal. India wheat, a plant of the buckwheat family, is grown largely in Vermont hill towns, the meal being used in lieu of buckwheat flour and as a cattle food. It rarely enters into trade. It was fed daily two seasons in comparison with wheat bran and with half and half cottonseed and linseed meals, to 12 cows the first and 11 cows the second year. Used in medium to small amounts, it seemed a fair substitute, pound for pound, of wheat bran, and nearly so of a mixture of equal parts of cottonseed and linseed meals; an outcome which its analysis would not have led one to expect but which is confirmed by the concordant results of the two seasons' trials.

Feeding values of cottonseed and linseed meals. Twenty cows were fed for nearly six months. Cottonseed meal seemed to possess a small though measurable advantage over linseed meal as a milk and butter making by-product; and since it cost less and carried a greater plant food content, it proved economically preferable.

Feeding value of so-called "cottonseed bran." Four cows fed 20 weeks. A pound of dry matter in cottonseed bran produced less milk and butter than did a similar amount in corn meal and bran, but on the basis of digestible dry matter was perhaps superior.

The feeding value of hominy feed. This breakfast food residue was fed daily two successive years, each year as compared with bran and with half and half cottonseed-linseed meals and the first year also as compared with gluten meal, 16 cows being employed the first and 11 the second year. It proved equal to average wheat bran as a milk maker and to be superior to a rather inferior grade thereof; but it was not the equivalent of either gluten meal or the cottonseed-linseed ration; neither was it as economical a concentrate as were these.

"Nutrene dairy feed," one of the first of the molasses feeds, fed to eight cows, was refused by seven.

Oat feed, fed for a month, seemed to have a value just about that of equal parts of bran and corn meal.

The feeding value of dried molasses beet pulp. This material, a residue from diffusion batteries of beet sugar factories mixed with residuum molasses, was fed for six months to six cows in comparison with wheat bran, and to five cows in comparison with silage. Pound for pound of dry matter it seemed essentially equivalent in feeding value to wheat bran and mature corn silage. At $12 a ton it was well worth trying; at $20, it was too costly to merit use.

"Nutriotone." A test of the effects of "Nutriotone," a condimental food, carried out by a former station officer, showed no beneficial results on the milk flow.

Heavy grain feeding. An increasingly heavy grain ration was fed to three cows. It began at 6 pounds and reached 12 to 14 pounds daily. The nutritive ratios ranged from 1:5.6 to 1:7.9 with 2 cows, and from 1:3 to 1:6 with the other. One cow maintained the flow and its quality for 24 days; another "responded to every additional pound of meal with an increased milk yield of better quality." Both shrank when put for 15 days on nearly equivalent amounts of a wider grain ration. When placed on another ration of equal weight but narrower ratio, one held her own, the other continued to decrease in yield. A farrow cow fed equal weights of bran and cottonseed meal, beginning with 6 pounds daily and increasing to 12 pounds, slightly bettered her flow. On 10 pounds bran and gluten feed she bettered it yet more; and on 10 pounds clear bran she lowered it. No unfavorable effects on cow or product resulted during the two months' trial.

Light and heavy meal feeding. Eleven cows were fed, some a grain ration with bran as a main constituent, others a grain ration made up of corn, cottonseed and linseed meals. The results were held to justify the statements that light feeds such as bran are often as good, weight for weight, as heavier meals, and that milk from bran fed cows creams less thoroughly by deep setting than does milk made by cows fed heavier meals.

Grain feeding at pasture. The records of 20 Franklin County herds fed little or no grain compared with those of 6 station cows fed grain, hay and silage, before, during and after the pasture season, indicate that full grain feeding at the barn and while the cows are on pasture, produces a much larger spring flow and maintains it considerably later in the fall. No attempt was made to learn whether the procedure paid.

Summer dairying vs. all the year dairying. The average records of about 10,000 Franklin County cows in 1892 were compared with those of the station herd. The former were summer cows, the latter calved at all times in the year. 4.11% fat is deemed the average for Vermont cows as a whole. The average fat percentage in the station herd was relatively uniform month by month, being practically constant (4.21 to 4.53% extremes); that for the summer calving cows was less so (3.69 to 4.94% extremes).

How much grain can be fed with profit to cows? This matter was under review for five years as follows:

1900—11 cows fed 6½ months either 4, 8 or 12 pounds of grain daily.
1901—15 cows fed 6½ months either 4, 8 or 12 pounds of grain daily.
1902—24 cows fed 6 months either 4, 8 or 12 pounds of grain daily.
1903—12 cows fed 6 months either 2, 4 or 8 pounds of grain daily.
1904—14 cows fed 6 months either 2, 4 or 8 pounds of grain daily.

The impelling motives were: (1) Vermont's heavy feed bill, approximately $10 per capita; (2) the fact that the money paid for feed mostly flows westward; (3) the ill-advised purchase of carbohydrates in over-abundance and the under purchase of protein; (4) the wide divergence in practice both as to amounts and kinds of grain fed; (5) the almost absolute dearth of data experimentally obtained, touching the relationship between the amount of grain fed and profit. The work falls naturally into two divisions, i. e., comparisons of low, medium and heavy grain feeding; and very low, low and medium grain feeding. The mere summing up of these several experiments occupied several pages in the original reports. The salient features, however, may be expressed as follows:

Does it pay to feed as little as 2 pounds grain daily? When 2 pounds were fed instead of 4, 68 cents were lost in butter product (rating butter at 20 cents) for each dollar saved in feed bills. When 2 pounds were fed instead of 8, for each dollar saved in feed bills 59 cents were lost in butter product at 20 cents per pound. When, however, skimmilk, rated at 15 cents per hundred, and two-thirds of the manurial values of the feeds are included in the reckoning, the outcomes were more favorable to the more liberal feeding and the figures $1.24 and $1.15 were substituted for 68 and 59 cents. The outcome in a comparison of this kind is bound to be a fluctuating one, depending on changing prices for feeds. Thus in 1903, using bran and brewers' grains selling at less than $20, it paid to feed grain liberally; while in 1904, using higher cost concentrates, the immediate outcome favored a low ration. In the one year the extra cost of grain was more than met by increased income for butter when the grain ration was doubled; and three-fourths of its extra cost was thus met when it was quadrupled, and skimmilk and manurial values were so much added gain. In the other year no adequate return was obtained from a usage of grain in excess of 2 pounds daily, either in butter or in butter, skimmilk and manurial values combined, an issue which seems to uphold the contention of those who argue for a restricted grain ration.

Yet it is not only a matter of immediate returns. No one could see Atalanta, in good flesh December 5, but lean and gaunt May 27 after 25 weeks of 2 pounds daily of grain, with hay and immature silage; or view the sharp falls in milk yield which followed curtailment of grain, or the partial recovery which paralleled their restoral, without realizing the relationship between grain and milk. Success seems to have followed restricted grain feeding in these trials; yet, one may well doubt whether a stinted grain ration will prove in the long run as profitable with good cows as will a more liberal one. Its effect on the persistency of the milking habit needs must be unfortunate. One has but to scan the records of the lightly fed cows for the past two winters and to note their gaunt condition to feel doubtful of the wisdom of feeding such very low grain rations to good dairy cows.

Does it pay to feed a low grain ration (4 pounds daily)? The substitution of an 8 pound ration for a 4 pound one was followed by a daily gain of 0.56 cents per cow one year and of 0.08 cents another year and only 0.07 cents during a third season. At no time did the increase in butter pay for the extra grain; but every time the comparison has been made the total increase in immediate cash (butter money), pork (skimmilk), and plant food (the enriched manure), has more than equalled the additional outlay for grain. The margin, however, has twice been so small as to be hardly worth reckoning. Viewed simply from the standpoint of immediate gain or loss the wisdom of feeding the extra 4 pounds seems open to question.

Does it pay to feed a high grain ration (over 8 pounds daily)? No. The first year's trials showed a gain of 0.48 cents; the second, a loss of 1 cent, and the third, a loss of nearly a cent and two-thirds daily per cow, when 12 pounds of grain were fed instead of 8 pounds. If butter returns only are considered the losses are yet greater. Not only may money loss be anticipated, but bovine health may be shattered and future usefulness be impaired.

Twelve pounds is excessive and unwise; 10 pounds may rarely pay its cost over a lesser amount; two pounds is too little, even with a full amount of roughage; four pounds, when roughage is good and plentiful, is likely to yield net returns nearly equal to those afforded by an eight pound ration, and to prove the better if skimmilk and manurial values are disregarded; but its residual effect on after-production may be unsatisfactory. When all the different factors are taken into consideration, from 6 to 8 pounds daily seem most advisable.

In these trials the roughages were of the best and were freely fed. The cows, even on a low ration, had enough to eat. The outcome would have been less favorable to low feeding had it not been for this fact. In lack of plentiful roughage supplies grain rations need proportionate modification.

The feeding value of alfalfa meal. Nineteen cows were fed nearly six months in trials comparing alfalfa meal with wheat bran and with distillers' dried grains. The alfalfa meal ration made less milk and butter, carried less fertilizing value and was fed at a loss, as compared with wheat bran ration, the meal costing $27 and the wheat bran $18.50. Had each cost alike the former would still have been outclassed. An alfalfa meal ration made one-seventh less milk, one-sixth less butter and the ration containing it carried one-sixth less plant food value than did one containing distillers' dried grains. It is utterly outclassed, even at equal prices.

"Protena," a proprietary article the basis and principal constituent of which is alfalfa meal, made as much milk as did a mixture of wheat bran, cottonseed and linseed meals, but 7% less butter. The ration carried but four-fifths the plant food content of its competitor, and was outclassed when financially compared.

Alfalfa products can hardly be considered economical unless sold at $18 or less.

The feeding values of silage and of hay. Six cows were fed on rations, one of which included and the other excluded silage. Seven percent less milk and butter were made when silage was omitted from the ration than when it was included. The quality of the milk remained unchanged. Rating hay at $10 a ton and silage at $3, there was a gain of 1⅜ cents daily per cow by replacing one-third of the hay by silage.

The feeding value of mixed silage of corn and soy beans. Four cows were fed for a month corn and soy bean silage in competition with corn silage. The addition of the soy beans neither bettered the silage appreciably nor augmented milk or butter yields.

The feeding value of a silage made from peas, vetch and oats. Six cows fed this silage while at pasture for six weeks made 6 pounds more butter than during the preceding six weeks on pasture supplemented by silage and fodder corn, and 32 pounds more than during the succeeding six weeks of barn life on corn and rye silages, which indicates that ensiled peas, vetch and oats may be as good as corn silage.

The feeding values of corn silage and of a silage made from soy beans and cow peas. Two cows, fed 12 weeks on corn silage and a silage of mixed cow peas and soy beans (which kept very poorly and was hardly richer in protein than was the straight corn silage), made less but better milk and essentially equal yields of solids and fat when somewhat more total dry matter in the mixed silage was fed. A hundred pounds of dry matter in corn silage proved superior to the same amount in the legume silage.

Relative values of corn silage and fresh fodder corn. Eleven cows, fed two weeks in early September on green fodder corn, shrunk 5% in butter yield. Nine cows during the same time, fed mature corn silage ensiled the previous year, gained 8%.

Feeding value of rye silage. Twelve cows were fed rye silage or corn silage during eight weeks. The rye silage was dryer, less readily eaten, and made 10% less milk and butter. Four cows passing from corn to rye silage, the latter fed four weeks later than the former, shrank 20%; three cows passing from rye to corn silage, gained 2%. The cows lost flesh on rye silage.

The "Robertson mixture." Two feeding trials were made of the so-called "Robertson mixture" (corn, horse beans and sunflower heads ensiled). The first one was made of little value by the slaughter of the herd because of tuberculosis; the latter was made with 6 cows for 16 weeks, the mixture being fed in comparison with corn silage. The claim made for the mixture was that on account of the added protein and fat in the horse beans and sunflower heads, 2 pounds grain could be saved to each 50 pounds of the compound silage, a claim which was put to test.

The cows did not eat the Robertson silage as readily as that made from corn. A fifth less dry matter was eaten from the Robertson mixture ration than when corn silage was fed. Essentially the same amount from beets or carrots. Since the dry matter from silage gained slightly in weight on the mixture ration. In this test the claims made for the mixture seemed upheld; yet notwithstanding, the Station does not recommend it unqualifiedly, owing to the difficulty of growing satisfactory stands of the horse bean.

Feeding values of corn silage and of roots. Eight cows fed 16 weeks stated that a pound of dry matter gave essentially the same returns when silage was fed as when it was replaced by a similar amount from beets or carrots. Since the dry matter from silage is less digestible than that from beets or carrots, it follows that a pound of digestible dry matter from corn silage yielded better returns than a similar amount derived from the roots. Both beets and carrots cost more to grow and yield less per acre than corn, and, per pound of dry matter, they produce no more and no better milk than does corn silage.

A very brief trial comparing Robertson mixture and corn silage with these two roots was made the previous year. Results seemed essentially alike as between the two roughages. But little stress is laid upon the outcome.

Corn silage vs. potatoes. Six cows fed for 12 weeks either on silage or on potatoes. A hundred pounds, both of dry matter and digestible dry matter, in silage proved superior to similar amounts in potatoes. The latter were eaten even more freely than was the silage, yet produced neither more nor better milk. At 15 cents a bushel they were more costly food for stock than was silage. The effect upon the quality of the butter was unfavorable.

Feeding value of pumpkins. Three cows were fed under conditions where pumpkins, seeds and all, were substituted for silage, about

2½ pounds of pumpkins being fed in place of 1 pound of silage. Practically the same production, but 5% more to the unit of dry matter was made on pumpkin feeding than on the silage ration. The quality of the milk remained unchanged.

In a second year's trials pumpkins were compared with hay and apple pomace, four cows being fed. The pumpkins when added to a hay ration, increased the milk flow 6%. The cows seemed in no way harmed nor was the butter injured. Pumpkins can serve only as a fall or early winter feed. Their equivalence to silage is in the proportion of 2½ tons to 1.

The feeding value of apples. Four cows were fed in alternate periods rations where apples replaced three-fourths of the silage. 8% less product was made on the apple than on the silage ration. The former contained, however, 8% less food; hence the unit of dry matter made as much on one ration as on the other. The quality of the milk was not altered. Pound for pound, apples did not prove equal to silage. Pound for pound of dry matter, they appeared to be nearly as useful. Apparently they have about 40% the feeding value of silage. No damage resulted to the cows from somewhat liberal feeding.

The feeding value of apple pomace has been under survey for many years. It has been fed freely in the fall to scores of station cows—both experimentally and as a staple food—with uniformly good results. Some of the concrete results may be stated as follows:

1889. Well relished when ensiled and apparently equivalent in feeding value to corn silage.

1901. From 3 to 4% more product was made on a pomace ration than on a silage ration.

1902. Seven percent more product was made on a pomace ration than on a silage ration.

1903. Practically the same production to the unit of dry matter was made on each ration.

At no time was the quality of the milk affected. Neither milk nor butter are injured by liberal feeding. Apple pomace needs no special care in ensiling. If leveled from time to time as put into the silo and left to itself uncovered and unweighted, it does well. It may be fed directly without being put in the silo.

The financial side of the proposition is most alluring. "Pomace at a dollar a ton at the barn is a great bargain and at a much higher cost is a fair equivalent of corn silage." A ton brings onto the farm 6 pounds nitrogen, 5 pounds potash and 2 pounds phosphoric acid worth, doubtless, well nigh a dollar as plant food. "It should be fed lightly at first until the cows get accustomed to it; then as high as 35 pounds daily may be fed without harming the cow or depleting the pocket book."

Effect of grooming of cows upon the milk flow. Eight cows in two seasons were uniformly fed, but were either groomed or left ungroomed in alternating periods. The first year no appreciable effect was observed; the second year, 4% less milk was made when the cows were groomed. The quality of the milk was unchanged. Grooming cows should tend to better the keeping quality of milk and the grade of the butter, but does not seem to add to the milk flow or its fat content.

Relation between water consumption by cows and barn and water temperatures. Water below 40° F. was drunk as freely as that which was warmer. Less water was drunk when the barn temperature was about 50° F. than when either higher or lower. Two cows during one winter.

Watering cows at will and at stated intervals. Eight cows for two seasons were uniformly fed and handled save that in alternating periods they were given water either twice a day or were allowed to drink at will, water standing in the stanchion. No change in quantity or quality of milk resulted.

Warming water for cows. Nine cows during two seasons were given in alternating periods water either warmed or cold. In the first year's trials the temperatures were 45° F. and 70° F.; in the second, 35° F. and 80° F.; otherwise their treatment was uniform. In neither case did appreciable differences occur in quantity or quality of milk. A net loss of 14 cents in 90 days occurred the second year over and above the expense of warming the water. The cows were amply fed and stabled in a barn the temperature of which was usually between 40 and 50° F.

Pig feeding. The experimental feeding of swine was pursued for 8 years. The salient results may be stated as follows:

In a trial of 2 Chester Whites, 2 small Yorkshires and 2 Berkshires, fed from ages of 5 weeks to 6½ to 7½ months, but little difference was observed justly to be ascribed to breed. What difference there was favored the Chester Whites. In a second trial of Poland Chinas, large and small Yorkshires, and Chester Whites, the latter "grew the fastest," but, with the first named "required the least food," while the "large Yorkshire made a pound of pork with the least cost of food." In a third trial Poland Chinas and Berkshires were equally successful; and in a fourth Berkshires outstripped Yorkshires.

The pigs in two years' trials averaged to use 1.43 pounds dry matter in food to make a pound of growth up to the time they weighed B. 10 (1890); 4:114-128 (1891); *J. L. H.* 8:86-92 (1894) (out of print). 53 pounds. This amount increased steadily as the pigs grew, until when they weighed 201 pounds it required 3.84 pounds of dry matter in the food to produce a pound of growth. Nearly all ceased to yield a profit after they reached about 180 pounds live weight.

The value of skimmilk in different trials ranged from 24 cents to 27 cents per hundred, averaging 25 cents. The manurial values averaged 61.5% of the food cost. Sour (thoroughly loppered) skimmilk produced just as good or a shade better results, pound for pound, as did sweet skimmilk. Two ounces of corn meal to each quart of skimmilk made a pound of pork at the least cost for food. Larger amounts of corn meal produced more rapid growth, but at an increased cost for food per pound of pork. A method of feeding early in life which tends to develop bone, muscle and digestive organs, rather than to form fat, builds a foundation on which greater profit may be made when heavy feeding begins in preparation for market. During the finishing off process 12 quarts of skimmilk daily per pig, with all the corn meal that would be eaten, produced a more rapid growth at less cost per pound than did 6 quarts of skimmilk under similar conditions.

It is usually stated that bulky or watery foods tend to promote stomachic and intestinal growth and to increase the shrinkage. Yet in a series of tests the shrinkage of pigs fed bulky foods was little if any greater than that of pigs fed more concentrated rations, while the shrinkage on watery and on concentrated rations were identical.

To the query whether it is "more profitable to feed skimmilk freely or to feed less, making up the shortage in grain"— or in other words, the relative economy of diluted or concentrated rations—the answers given were: "No marked effect one way or another"; and "the cost of food per pound increase and the profit slightly favored the less watery ration."

The relative feeding values of skim and butter milks are stated in one case to be as 5:4 and in another as equivalent.

The relative feeding values of corn meal and whole corn were twice determined with results "slightly" in one case and considerably in the other in favor of the meal. Doubt was expressed "whether the gain was equal to the cost of grinding." Feeding meal wet gave better results than feeding it dry.

Whey fed freely with bran proved more economical than did skimmilk freely fed with corn meal, but not more so than did smaller quantities of skimmilk fed with meal.

With pork at 4½ cents dressed weight, skimmilk fed freely was worth 12 cents, fed sparingly 18 cents, while whey was worth 11 cents per hundred, these figures being predicated on a calculation which subtracts grain cost from total receipts and allows manure to offset care.

Beekeeping. Trials made during three seasons were held to warrant the following statements:

1. No perceptible difference was noted between different sized frames in wintering or building up in the spring.
2. Double brood chambers for wintering and spring building up did not prove useful.
3. Stimulative spring feeding proved injurious.
4. Bees will make use of scrap wax in comb construction during the honey flow.
5. The Langdon non-swarmer proved a failure.
6. The periodical removal of all drones and drone brood failed to prevent swarming.
7. The removal of the queens during honey flow was of no avail.
8. No difference could be detected by experts in the quality of honey produced under otherwise similar conditions upon different comb foundations. The Weed new process foundation was thought superior.
9. The honey made by bees fed with cane sugar syrup did not differ materially in composition from that directly adulterated. Such as was made when the bees were fed but 20 pounds a week was somewhat more like normal honey than that made when they took 20 pounds a day. In each case some laevulose (honey sugar) was formed and a trace of acid added.
10. Feeding back extracted honey for section-filling did not succeed well.
11. Tests made seem to indicate that the winter temperature of the hives may vary without detriment to the bees.

DAIRY HUSBANDRY

Variations in milk. Data dealing with milk variations have been often published. They may be summarized as follows:

Over 400 cows on early pasture May 6-June 6, gave milk with highest and lowest fat percentages (daily samples) as follows: 3.63 and 4.03. A herd of 13 cows during the same time varied from 3.63

to 4.62%; on successive days, 3.75 and 4.29%, 3.88 and 4.62% were noted.

Monthly variations during a lactation period. A study of 16 lactations prompted the following statement:

1. All cows shrink in milk flow as the lactation period advances. If farrow, almost no change in quality ensues from calving to drying off, provided they remain farrow. If in calf, the milk increases in quality as it decreased in quantity. This increase is very slight for six months, but becomes pronounced just before drying off.

2. Cows calving in the spring give more milk for 3 months after calving than those calving in the fall. This situation is reversed from the 7th to 9th months. Fall cows show smaller variations in milk flow than cows calving in the spring.

3. For a few weeks after calving, milk is very variable in quality, being usually thinnest just after calving and slightly richer during the next two weeks.

A review of 108 lactations led to statements as follows:

Quality. The spring cow rapidly increases the fat content of her milk, beginning about five months after calving; the summer cow starts in about the third month, while the fall cow maintains fairly even quality throughout lactation, seldom improving it more than 0.5%. The solids-not-fat content is most uniform month by month in the fall cow's milk, that of the milk of spring cows lessening somewhat in the summer time.

Quantity. The fall cow "held out" better than the spring cow, and as a rule gave larger yields.

Extreme variations in quality during lactation. The greatest variation in the milk of 115 cows was 3.06% fat; the least, 0.33%; the average, 1.26%. The average variation of spring cows was 1.62% fat; of fall cows, 1.08%; of summer cows, 1.25%. The thinnest milk was given from the 2nd to 4th month of lactation, the richest after the 7th or 8th. Just after calving the milk is thinner in fat and in solids-not-fat than just before the cow went dry. The average, greatest, and least changes were respectively for fat and for solids-not-fat 1.13, 2.35 and 0.49%; 0.47, 1.94, 0.42%.

Variations from year to year. Most cows give about the same quality of milk year after year, beginning at the first calving. There is no general tendency for it to become either richer or poorer as the cow grows older. From one calving to the next cows may vary its quality perhaps 0.15% and rarely more than 0.25% fat. But 6 of 43 cows changed the fat content 10% in successive years.

The effect of age on the yield and quality of milk. The year records of 99 cows, comprising 427 years of bovine life, were studied to note the effect of advancing age upon milk yield and quality.

1. *Milk flow.* At the outset and until seven years old the general trend was upwards. The eighth year flow tended to be lower than that of the seventh or ninth and to resemble that of the tenth year. No cause was found nor is stress laid upon this sag. From the ninth year onwards the trend was downward.

2. *Total solids.* In 32 cases the trend is downwards; in 3, upwards; in 10, level.

3. *Fat.* In 29 cases the trend is downwards; in 3, upwards; in 14, level.

4. *Solids-not-fat.* In 23 cases the trend is downwards; in 9, upwards; in 14, level.

A comparison of these results with those derived elsewhere show lack of uniformity. The downward quality trend is borne out in two other studies but is opposed by yet others. The differences, however, one year with another are in no case large. Heifers usually give nearly their lifetime average fat content in their first lactation. The effect of advancing years is not important until old age becomes imminent.

The quality of the milk of strippers. Stripper milk is richer in fat and solids-not-fat and of a higher specific gravity than the average of the milking period if the cow is in calf. If she goes dry when farrow or when but recently served, the quality is not usually enhanced.

Variations due to breeding. In several cases the fat content of a heifer's milk closely resembled that of their grade Jersey dams. The sire was from very rich milking stock. A heifer, whose dam was a grade Ayrshire, sired by this bull, gave milk a percent better than did her dam. One heifer gave poorer (—0.39%), another better (+0.51%) milk than their respective dams, their sires being unknown. Two Holstein heifers gave a little poorer milk than their dams. The statement is hazarded that "in a herd already giving a good quality of milk the farmer is confined to selection as his method of increasing the richness of milk, breeding being used to preserve what has been gained by care, feed and selection."

The change from barn to pasture. "The food, environment and mode of life of the pastured cow are utterly unlike those she encounters in the stable. So profound a change may well affect her milk flow. That she makes more milk when out of doors is well understood; but whether it is richer or poorer in fat is less certain."

This matter was under survey during eight seasons. Three quite distinct sets of results were obtained: (1) An immediate and decided improvement followed, in from two to four weeks, by a return to the pre-pasture quality; (2) a slower change with a tendency toward improvement; (3) no change in quality. Study of the weather conditions of the several years, and their comparison with the tabulated data was made without enlightenment. Neither could a relationship between the stages of lactation and quality changes be established. Just why the herd gave no better milk on pasture than in the barn in 1895, 1897 and 1898; and the reason why the cows gave better milk on pasture than they did in the barn in 1896 and from 1900 to 1902, are not understood; but the facts are beyond dispute.

However, it is clear at any rate that no poorer milk results from pasture feeding, even when the flow is considerably augmented. At least as good or better milk, and more of it—and rarely a thinner milk, no matter how much more there is of it—is the general outcome. It shows how irrational is the state law which lowers the milk standard for May and June because of a supposed thinner milk made on pasture feeding.

The effect of fatigue on the milk flow. Three trials were made of the effect of fatigue on the milk flow, the cows being driven 10 to 12 miles and shipped 50 to 70 miles by rail. In the first trial with 25 cows, half gave richer milk the night of their arrival and all richer milk the next morning, than they did two weeks later, the fat being the most variable constituent. The quantity was unfavorably affected. In the second trial it was found that fatigue lessened the flow temporarily; affected its quality seriously for the first one or two milkings, and raised the quality after a little while. On the third trial six cows, 18 hours en route and not milked during this time, showed temporary enrichment of the milk for a day or two. Apparently there was no serious milk shrinkage. It seems safe to conclude as a result of the three trials that fatigue tends to lessen the flow temporarily, and variously to affect the quality for one or two milkings. The folly of testing milk before a cow has become accustomed to her new surroundings is clear.

Effect on milk flow of a change of quarters. The station herd, having been driven three and a half miles to a new barn, gave the two days following as compared with the two days before the change, 6.5% more milk solids. The general yield bettered, the general quality lowered.

The effect of abortion on the milk yield. Abortion in the station herd ceased after thorough disinfection with sulphur and plentiful injections of laudanum. There is no conclusive proof that this procedure led to the cessation of the disease.

Two different studies with 4 and with 6 cows led to the statement that abortion entailed: (a) A shrinkage of one-third in milk yield; (b) a gain of one-tenth in quality; (c) a shrinkage of nearly one-third in butter yield; (d) a more even quality of milk throughout the milking period.

The effect of weather on the milk flow. Trials designed to discover the effect of weather changes on the milk flow were made for three years. The first covered 30 herds from May 6th to June 6th, and four from June 7th to July 24th; the second covered the period from July 20th to September 15th, the station herd being used; a third covered the remainder of the pasture period, September 15th to early November, the station herd being used; and the last from February 25th to March 30th, using 7 cows stabled in a poorly constructed barn on a bleak hillside. The records of the 75 cows in the world's fair (1893) test were also used.

1. *Fall.* Nearly two-thirds of the changes in total solids percentages and over half those in fat were inverse to thermometric variations.

2. *Winter.* Nearly two-thirds of the changes in fat percentages were inverse to thermometric variations.

3. *Summer* (*soiling*) (world's fair). Over half the changes in total solids percentages and three-quarters of the changes in fat percentages were inverse to thermometric variations.

4. *Spring and summer* (*pasture*). 61% of the changes in the quality were in the opposite direction to changes in temperature.

5. *Summer* (*pasture*). 68% of the changes in total solids, and 54% of the changes in fat, were in the inverse direction to temperature changes.

6. These five tests, covering practically the entire year, and the conditions of pasture, summer soiling and winter barn feeding, point directly to the conclusion that the tendency of cows is to give from day to day richer milk when the temperature falls and poorer milk as it rises; or, in other words, the quality of the milk (solids and fat) tends to vary inversely to temperature changes.

Fast and slow milking. Eight cows milked slowly seemed to give as much and as good milk as when manipulations were rapidly done.

Milking two and three times daily. Two trials were made, using 2 cows, comparing diurnal with triurnal milkings (5 A. M. and 6 P. M.; 5 A. M., 1:30 and 8 P. M.) When milked thrice each cow gave the most and poorest milk in the morning, less of the richest milk at noon, and the least of a medium quality at night. The fat content only fluctuated, the several solids-not-fat remaining unaltered. The trials seemed to indicate that as a regular farm practice there is not enough to be gained from an extra milking to repay its cost. As a temporary means of increasing the flow it may prove of use.

A trial of the Hegelund or Danish method of milking. In 1895 four mature cows and three heifers were used in a trial of the Hegelund system, as well as of extra thorough stripping. The manipulations take from three to five minutes in each milking. The extra milk and butter obtained hardly repay the cost of extra labor of the Hegelund method; and the extra stripping, from which a return of 2¼ pounds of butter was gained, was done at a decided loss. If persistency of the milking habit and a more perfect udded development are encouraged, the adoption of the procedures has justification, particularly with heifers. This phase of the matter, however, was not studied. The additional load of dirt, dandruff, hair, dried manure, bacteria, etc., which fall into the milking pail because of the udder manipulation, is a distinct detriment, which, however, the use of a covered pail would tend to obviate. Incomplete milking causes large losses; but that any special virtue is possessed by a given set of manipulations over thorough stripping seem as yet unproven.

Cream raising by dilution—deep and shallow settings. In trials designed to determine whether successful gravity creaming could be secured without ice by the addition of hot or cold water, the following results were attained:

1. The usual method of deep cold setting did as effective work as any gravity creaming process and does not entail some of the disadvantages of other methods.
2. The addition of snow or pounded ice to the milk in the deep can caused good creaming, perhaps as effectual as by the usual method.
3. The direct heating of milk and setting at 58 to 60°, or its dilution with large bulks of cold water and setting at any degree, produced relatively poor creaming.
4. The heating and increased fluidity of milk caused by adding from a quarter to a third its bulk of hot water (130-150° F.), produced when set in water at 58-60° or shallow in cool air, as effectual creaming as did ordinary settings; but it entails increased tank room, thinner skimmilk and a rapidly souring cream.

5. There seemed little preference as to the use of hot or cold water or of none at all in deep air settings.

6. Nothing was gained by dilution, either hot or cold, in cool shallow setting.

7. Delays in settings and manipulations of the milk prior to setting seemed to affect the deep setting creaming more than shallow setting creaming.

Cream raising by dilution. Fresh cows' milk diluted with ¼ to ⅛ water at 130-135° F., creamed better by deep setting at 55-60° F. than did undiluted milk. No gain ensued by this treatment of stripper milk at 55° F., but at 60° F. gain ensued.

The addition of one-fifth part ice water to cold deep set milk was followed by poorer creaming and churning.

Dilution separators. Trials of the "Wheeler Gravity Cream Separator" (wherein it was advised to dilute milk with equal bulks of cold water, to allow it to stand two hours and to skim), indicated that the method was faulty in that from 13 to 40% of the total fat was lost.

Churning experiments. One hundred and twenty churnings afforded data held to warrant the following conclusions:

1. The percent of fat in the butter appears lessened by thinning the cream, by increased churning temperatures, by increased cream acidity, by lengthened time of churning, and by changing from a separator to a deep setting system. The fat percentages of sweet and sour cream butters were closely alike.

2. The percent of curd in butter did not seem affected by the length of time or the varying temperatures of churning. The sweet cream butters contained more curd than those made from sour cream; and the deep setting butters, more than did the separator made goods.

3. The churnings were most exhaustive with thick and ripened cream at low temperatures, while varying acidities, length of churning and methods of cream separation showed little effect.

4. The conditions most favorable in these trials to the exhaustive churning of a firm butter of high fat content appeared to be: (1) a thick cream containing 10 to 16% of the original milk; (2) ripened cream, unless churning at 54° or below; (3) a low churning temperature.

The effect of freezing milk on creaming and churning and upon the quality of the butter. A series of trials were made wherein milk was divided into two lots, one-half allowed to freeze and the other handled in the usual manner; then churned, the butter worked and scored.

Neither skimming, ripening nor churning appeared to be impaired. Not so, however, with the scoring. The average scores of two sets of 15 lots each were: frozen butter, 93.2; normal butter, 93.5. Freezing tended very slightly to lower the grade of the butter, yet freezing *per se* is not necessarily a menace to good butter-making. It should not be inferred, however, that infrequent creamery receipts, delivered more or less frost bitten, will make as good a butter as if they had been delivered unfrozen.

Mechanical losses in handling milk. BUTTER. More or less loss of the solid material ensues in handling milk for the making of butter. This is shown by the fact that the sum of the solid ingredients found in the products (butter, skim and buttermilks and slops) does not equal the amount in the whole milk used. This loss falls almost entirely on the fat. The casein and albumen, milk sugar, and ash in the products check fairly well with those in the original milk, but the fat does not. This loss of fat is inversely proportional to the amounts of milk used and to the care taken in its handling, decreasing relatively with increased volume of milk handled and with greater care. The loss is a purely mechanical one, due to the greater viscosity of cream as compared to skimmilk. If the cause were chemical or biological as great proportional destruction would ensue with large as with small lots of milk. The mechanical losses in 22 days' survey of the operation of a small creamery approximated 0.9%.

CHEESE. Three days' work at a cheese factory indicated that mechanical losses were less important than in butter making. The objects of the two processes are opposite. One makes a viscid product, butter, the other a less viscid one, cheese. The nature of the products and the method of handling them favors greater mechanical loss in butter making than in cheese making.

Aeration of milk. Milk was divided into three lots, one set in deep setting at once at 96° F.; another run over a Star aerator without cooling and set at 96°; another similarly aerated and cooled by the same operation and set at 49°. This operation was repeated nine times. Similarly three lots of milk were handled by the Wood aerator, which divides milk into streams instead of spreading it in sheets, the temperatures being 92°, 82° and 67° respectively. The completeness of creaming was impaired by cooling but not by aerating in the former case, while in the latter there was no effect one way or another. Milk aerated and cooled by the one operation kept sweet one-eighth longer than did that not thus handled. The keeping qualities of milk aerated in such a manner that its temperature was maintained was not enhanced.

Making cheese from different qualities of milk. Cheese was made of milks testing 3, 4 and 5% fat. The fat losses were nominal, ranging from 0.17 to 0.30% fat; 9, 10⅝ and 11½ pounds cheese were made per 100 pounds milk. The cheeses were rated at 7½, 8¼ and 8¼ cents. It is stated that milk containing much over 4% fat can be more profitably made into butter than into cheese; that milks carrying 3-4% fat, when paid for on the butter fat basis, are accorded a just return; that such payments are less exact for milks below 3 or above 5%; and that the maker's skill and market considerations are important factors.

Changes in the ripening of cheese. Tests of three days' makes indicated that during the first month the main changes were lost moisture, a possible mechanical loss of fat, and slight loss of casein. The cheeses were but slightly cured, and were very mild and moist. Hence this statement at most only indicates initial changes.

Paying for separator cream at the creamery—cream testing. Dairymen who sell hand separator cream to creameries often fail to receive their just dues, owing to faulty sampling, testing and accounting. Suggestions are made as to sampling methods. The moderate warming of the sample and the use of a fine sieve and pestle are urged as means of promoting thorough mixing and accurate analysis.

The absolute necessity of testing a full 18 grams of cream is emphasized. Weighing the cream into the test bottle is the only known means whereby accuracy may be attained. A study was made of a method of analyzing separator cream relatively rich in fat, which had temporary vogue in certain Vermont creameries, consisting of heating to temperatures of 140 to 150° F. prior to pipetting and the use of a correction factor. The results were unsatisfactory. About 80% of the results were concordant, but 60% of the richer creams showed wide divergences. Individual differences served to make correction factors unreliable when applied to rich cream.

A larger "surplus" is due to patrons who furnish cream than to those who deliver milk. A higher price per pound of butter or of butter fat is similarly their due. The extra "surplus" averages 3%; the extra price is usually close to a half cent. The reasons why cream patrons should be thus favored are discussed at length and examples cited. Several examples are given of the sundry methods of determining milk-fat and cream-fat surpluses, of calculating payments on the "butter basis" or on the "butter-fat basis," etc.

Tests of cows at state fairs—home vs. fair grounds. Trials of cows were made at the state fairs of 1889 and 1890, nine cows being entered in the first and six in the second test. The trials were 24 hours long. Milks were deep set, creams ripened 24 hours and churned at once. The milks were of course sampled and analyzed. In each case similar comparisons were made with the same cow at home under normal conditions amid familiar environments. The conclusions as to the validity of fair ground tests are stated as follows: The effect of worry and confusion on the milk flow is variable. Some cows made more at home, others seemed stimulated by excitement and nervousness, and made the better showing at the fair grounds. Nervous excitement tended, however, to lessen the quantity of milk ingredients and variously to affect quality. The true "butter test" of a cow can hardly be made at a great fair as well as at home.

A comparison of udder conformation and of milk production. Do cows with ill-shaped udders make less butter on that account? The mature cows in the station herd were carefully surveyed and grouped into three lots; those with well-balanced, those with fairly well-balanced, and those with ill-balanced udders. The result was not strongly indicative one way or the other, but tended to bear out score card findings. Four out of five cows with well-balanced udders made more butter than did the average of 18 carrying fairly well-balanced or 11 with poorly-balanced udders. They also made more than the 12 year herd average (324 pounds). Per contra, 8 out of 11 with poorly-balanced udders made less butter than did the average of the 5 whose udders were well built or of the 18 whose glands were fairly well formed; and their records were all below the 12 year average.

Forty-six percent of the milk solids and fat were produced from the fore quarters of 5 cows and 54% from the hind quarters.

A comparison of score card judgments and of milk and butter records. A comparison of the results of the scorings of registered and of high grade Jerseys and of registered Ayrshires in three different herds, with their production records for milk and butter. The milk and butter yields of 83 cows for periods of from 1 to 8 years were compared with scorings. Nineteen cows scored 90 and above, 20 scored 88 or 89 and 12, 87 or below. These groups averaged milk and butter yields in the order stated: 6478, 6263 and 5699 pounds of milk, and 321, 325 and 286 pounds of butter.

The high scoring show ring cows were really in the long run little if any better producers than their less well-equipped sisters. But, on the other hand, the relationship between lack of conformation to dairy types and lessened production was clearly shown. The "poor lookers" were poor yielders and the show ring verdict did them no injustice. But in awarding prizes to cows which are really inferior as producers to others which do not look quite as well, and consequently do not score as high, it does do injustice. The importance of attested milk and butter records is recognized by breeders' associations. Why not in the score card?

Bovine tuberculosis. The discovery of the serious infection of the station herd in January, 1894, led to its slaughter and to the publication of a bulletin, a summarized statement of which is appended. This bulletin, together with the action taken by the state cattle commissioners, predicated largely on the statements contained therein, led in the fall of 1894 to the first enactment in Vermont looking toward the control of the disease under state auspices, a policy which has continued to this day.

Tuberculosis was discovered in the station herd in January, 1894, by means of the tuberculin test. But two cows were out of condition, yet 24 animals reacted. The post-mortems confirmed the test. Two animals which did not react showed no disease upon slaughter. The distribution of the disease was: lungs 90%, udder and its glands 73%, intestines and mesenteric glands 50%. Physical examination alone did not detect disease in several cases. Six of the cattle were bought from (probably) infected herds. The barn was disinfected by burning sulphur and the use of corrosive sublimate

1. *Prevalence and history.* Tuberculosis is the general name for a class of diseases which attack various organs and which both man and animal readily contract. The human death rate from all forms of the disease is about one in four. Cattle are affected in various proportions in different parts of the world. The extent of bovine tuberculosis in this country cannot be accurately stated owing to the lack of systematic inspection. The disease has been known from antiquity

2. *Cause.* Its sole and exciting cause is a germ, *Bacillus tuberculosis*, a parasitic, microscopic, rod-shaped plant which lives in the animal body, has great vitality, resists heat, cold, moisture, drought, decay and often the process of digestion. It is killed by boiling, by long continued heat at from 150 to 170°, as well as by sunlight, air and certain chemicals. Infection occurs: (1) by breathing the germs; (2) by swallowing the germs; (3) by their entrance through a cut or wound. The main sources of infection are: (1) the dust of the dried spittle of consumptives, or other tuberculous matter either breathed or swallowed; (2) contact with tuberculous material or people; (3) the meat and milk of tuberculous animals.

3. *Accessory causes.* The *Bacillus tuberculosis* is the sole cause of the disease; but there are conditions so favorable to its development

that they are well termed accessory causes, although strictly speaking they are not causal. Among these conditions are: (1) hereditary predisposition; (2) unhealthy surroundings, poor ventilation, uncleanly, dark, damp, hot and cold stabling, lack of exercise, climatic influences; (3) faulty feeding, under-feeding, over-feeding, feeding on unwholesome or indigestible materials, over-production; (4) faulty breeding, in and in breeding, early, late and frequent breeding, intensive breeding, lack of constitution; (5) ill-health, temporary predisposition; (6) physical constitution.

4. *Symptoms.* The symptoms of bovine tuberculosis are more obscure than those of the human disease, and often baffle detection. Any attempt to describe them would probably prove misleading

5. *Lesions.* Wherever the germs locate in the body they irritate the tissue, forming round nodular masses. These newly formed tubercles are usually soft and red. In chronic cases they become cheesy, limy, and disintegrate and run together, forming yellowish, caseous, pus-containing masses of various sizes imbedded in the diseased organs. The lungs, linings of the chest and abdomen, the lymphatic glands and the bowels are most often diseased. Sometimes the tubercles are too small for the naked eye to see.

6. *The tuberculin test.* Tuberculin is made from pure cultures (growth separate from all other germs) of the tubercle bacillus, concentrated, sterilized (to kill all germ life) and filtered. It contains the chemical poisons created by the life functions of the germs. It is successfully used to detect tuberculosis in cattle. A small quantity injected into a tuberculous animal usually produces a fever; but if the animal is healthy and it is properly used there should be no rise of temperature. A rise of 2° F. above normal is ground for suspicion. The tuberculin test is fallible. Mistakes have been made in its use, and it has sometimes failed in careful hands. It is, however, much more reliable than any other known means of diagnosis. If properly made and used, it cannot cause tuberculosis.

8. *Prevention.* Both human and bovine tuberculosis are preventable, and the means which may be taken to prevent its spread are: (1) Official inspection of cattle, meat and milk; (2) the destruction or disinfection of human spittle; (3) careful disinfection of places occupied by tuberculous men or animals. The stock owner, so far as possible, should keep his cattle under healthy conditions, should keep each animal in its own stanchion, should isolate suspected animals, should buy cautiously, should exclude human and animal consumptives from the barn, should test all purchases, should kill and destroy diseased animals, disinfect the premises and test the rest of the herd.

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UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 139

Forest Service Publication No. 1.

MARCH, 1909.

Preliminary Statement regarding the Forestry Problems of Vermont.

BURLINGTON:
FREE PRESS PRINTING COMPANY,
1909.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 189: PRELIMINARY STATEMENT REGARDING THE FORESTRY PROBLEMS OF VERMONT

FOREST SERVICE PUBLICATION No. 1

By Austin F. Hawes, State Forester

The purpose of this preliminary publication is to explain in a brief way, for the benefit of those unacquainted with the subject, what forestry is; to outline the work of the state forester's office; and to give instructions regarding one of the most important branches of forestry, namely, forest planting. Other publications will follow from time to time, containing information about the various forestry problems of Vermont.

I. Definition of Forestry

Forestry is the cultivation of a forest crop; just as horticulture is the cultivation of gardens; and as agriculture in a broad sense is the cultivation of the soil for food products, etc. The important forestry measures fall into three classes,—

(1) Planting forests.

(2) Improvement of growing forests.

(3) Harvesting mature forests in such a way that a young forest of the valuable kinds will replace the removed timber.

Planting is the phase of the subject which first appeals to land owners, and has always constituted the first step in forestry. This is because the work is simple and the results are soon evident. In New England, especially, where there is so much land formerly farmed but now lying idle, forest planting is bound to be an important form of investment. (See pp 25-26).

The improvement of woods is brought about chiefly by thinnings, which correspond to the weedings or cultivation of the garden crop. It is just as important that man should assist nature in regulating the supply of light and moisture for the trees of a forest as for turnips or potatoes. There are few soils too deficient in chemical constituents to support forest growth, so that fertilization is unnecessary and impracticable; but the retention of moisture in the soil and a sufficient supply of light are essential. In many parts of Vermont the removal of these poorer trees can be done profitably. Even if the proceeds are less than the cost,—and it must be remembered that farm weeds bring no returns,— the expenditure should be considered an investment, just as that for planting; and will, if made judiciously, be returned with interest in the form of valuable mature timber.

The most difficult forestry operation, and therefore the one least practiced, is the harvesting of mature timber in a conservative manner, so as to secure natural reproduction. Lumbermen who have cut land clean are often willing to invest in replanting the land which by proper cutting might be covered with a natural young growth. To be sure, this provision for a second growth calls for an investment, and it is sometimes a difficult question to decide whether a small investment in providing for a natural seeding or a large one in establishing plantations is preferable. In general, however, natural reproduction should be secured wherever possible, and plantations confined to open lands.

FORESTRY FOR LUMBERMEN

From the above references to investments it is evident that forestry is a business of a permanent or at least long time duration. In this it differs from past lumbering, which in this country has been largely a speculative business—the purchase of timber tracts at low figures followed by appreciation of values due to a growing scarcity of lumber. As long as lumbermen could continue this process of cheap purchase followed by denudation, their interests were opposed to forestry. In a small way this is still done by the portable mill man. Those men who have thousands or hundreds of thousands of dollars invested in sawmills and pulp concerns now find themselves confronted with the necessity of getting their supply further and further from the mill, with the prospect that in the not distant future the supply will be exhausted. For this reason these men must in the future be the strongest advocates of forestry, and many have already become so. To manage their large tracts under forestry principles will require the investment of considerable sums of money. Good forestry will secure the greatest permanent net income from this investment, just as good railroading demands a permanent rather than a temporary income.

FORESTRY FOR FARMERS

While the farmers of Vermont form a larger class of land owners than the lumbermen, their land holdings are smaller, and they have been accustomed to rely for their annual income only on the cleared part of the farms. The woodlot has been held as a sinking fund upon which to draw as a last resort in financial trouble, or for some special purpose. The best farmers, who are continually bringing up the productive capacity of their fields, have entirely overlooked the fact that their woodlots are producing only a small portion of the income which they could produce. To the owner of one hundred acres of woodland it is an important question whether that woodland is deteriorating or improving; and whether it is producing annually one-half a cord per acre, worth as stumpage fifty cents, or five hundred feet of lumber, worth four dollars. The figures represent a difference in his annual income of from fifty dollars to four hundred dollars, and they are not extremes. The farmer must not make the mistake of supposing that this income is to be removed each year. It may be necessary to leave it for a number of years, but so long as his woodlot is maintained in good condition he can be just as sure that he is saving this income as if he deposited it in a bank. The only way to maintain this condition is by thinnings, and he can make these economically by cutting his year's wood supply, and that which he wishes to sell, from the poor trees here and there, instead of cutting clean. There is hardly a farm in the state upon which there are not some open areas which are better adapted for producing forest than for other purposes. These should be cleared and planted.

Too many farms have been sold for less than the value of the timber on them. When the trees are mature, they should be sold at a stumpage price; or at least the price received for the lot should be based on the amount of timber and current stumpage values. Forestry principles require that woodland shall no longer be stripped and left naked, and the farmer is best able to enforce this requirement.

FORESTRY FOR THE OWNER OF COUNTRY ESTATES AND FOR INVESTORS

We have pointed out the two classes of land owners most affected by forestry; lumbermen and farmers. There is still a third class, which, although not really so vitally interested, has nevertheless led in the forestry movement. In this class are people who have purchased estates in the country; summer hotel companies; recreation camps; water companies; and a growing class of moneyed men who are buying forest property primarily as a good investment. These owners are all interested in having every portion of their land producing what it is best fitted for, and especially desire to grow forests on account of their beauty. Water companies have a further interest in that their water sheds can be maintained in the best condition only by a forest cover.

THE INTEREST OF THE TOWNSHIP IN FORESTRY

The chief interest of a township in forestry, as in any general subject, is a financial one. If the land owners of a community find it to their interest to practice improved methods of agriculture and forestry, it is no less to the advantage of the town government that these be practiced. With towns of rough topography and comparatively little farm land, the condition of the forests may make the difference between prosperity and pauperism. Forest property properly maintained may supply work and bear the burden of taxation for a considerable population. But as soon as it is wasted, the demand for labor is lost, assessable value is destroyed, so that the rate of taxation must be increased until it may induce depopulation.[1]

In many townships the aesthetic value of forests cannot be overlooked. There is a money value as well as a sentimental value in this, for the industries dependent upon a summer population can no longer be overlooked in Northern New England.

It is therefore the duty of the officers of such townships to develop the forest fire service as prescribed by law, so that forest property shall be more secure; and to realize that excessive taxation of woodland will only hasten the destruction of the property and permanently impoverish the town, whereas an equable taxation that shall encourage forestry will be its best policy.

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[1] In this connection, see article in Vt. St. Bd. Agr. Rpt., page 71-74. 81-83. (1903).

VERMONT'S INTEREST IN FORESTRY

The interests of the state in forestry are the same as those of the township on a larger scale. The importance of the lumber industry to Vermont is shown by the following table:

LUMBER CUT OF VERMONT, 1906—514 MILLS

Species	*M. feet*	*Total value*
White Pine	24,944	$ 433,748
Hemlock	56,042	925,336
Spruce	136,867	2,366,094
Maple	34,859	530,249
Basswood	9,482	154,259
Birch	29,577	454,033
Beech	14,976	205,981
Ash	5,184	106,072
Others	17,491	298,232
Total	329,422	$5,474,004

OTHER FOREST PRODUCTS

	Total value
4,760 slack barrel staves	$ 25,050
8,990 cords hemlock bark	64,473
34,968 cords pulp wood	290,384
3,579 M board feet used in veneer	44,276
4,779,870* lbs. maple sugar	464,132
160,918* gals. syrup	134,821
	$1,023,136

Just how much the fuel wood, railroad ties, poles, etc., cut in the state would value we have no means of knowing, but it is safe to assume that it would be between two and four million dollars, so that the total annual product of the Vermont forests is probably about ten million dollars.

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*These are figures for 1899, a year in which the sugar yield was abnormally low.

The census of 1900 gave the area of Vermont as 5,846,000 acres. This land area may be classified as follows:

Forest and waste land within farm boundaries	2,597,000 acres	= 44%
Forest and waste lands not within farm boundaries	1,122,000 acres	= 20%
Total area of forest and waste land	3,719,000 acres	= 64%
Improved farm land, including pasture	2,127,000 acres	= 36%

While it is possible that some forms of agriculture might be practised on some of the waste land, it is evident that considerably over half the state's area should be devoted to the production of forests; and that forestry is therefore of very vital financial importance to the state.

The total value of food products of the state, exclusive of live stock,[1] is approximately $25,000,000. The interesting thing shown by these figures is that the average gross income from the farmed land approximates $11.70 per acre, while from the woodland it approximates $2.70. Undoubtedly the latter figure is much below what it should be, even if the annual cut represented the annual growth, as it does in farm products. As a matter of fact this forest revenue is very largely drawn from the principal or capital, and therefore does not represent income. Statistics show that this is the case, and that the cut is diminishing.

VERMONT'S LUMBER CUT

1880	322,942,000	feet
1890	370,155,000	"
1900	365,869,000	"
1906	329,422,000	"

Defebaugh, commenting on this decreased production of Vermont in his "History of the Lumber Industry of America," says;"Inasmuch as the mechanical advantages for lumber harvesting are greater than ever and the demand for lumber increasing, the only conclusion is that the shrinkage is due to the disappearance of the forests."

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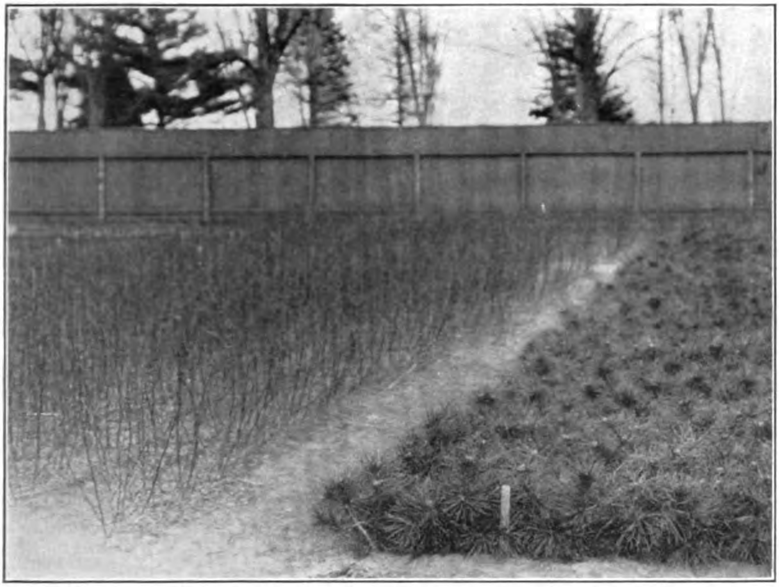
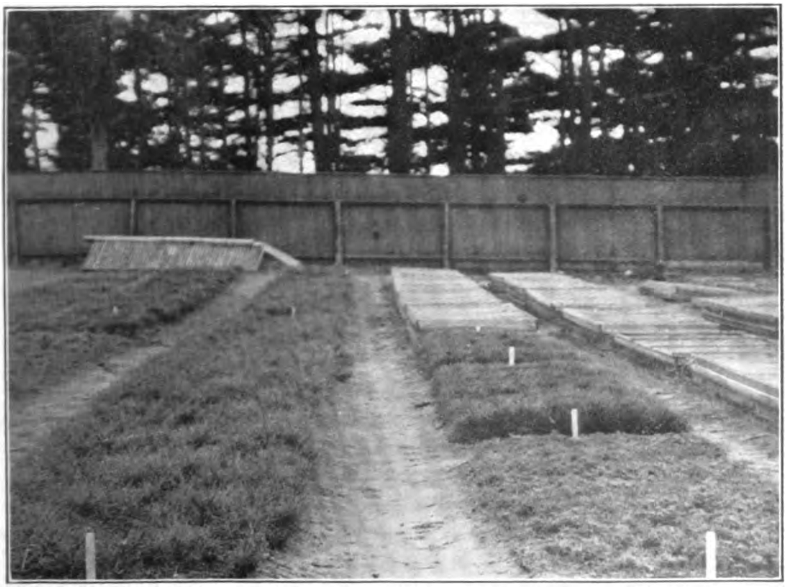
[1] The value of live stock is not included because it is comparable to the finished product of the forest, whereas our values are for raw materials.



Locust and Scotch Pine in State Nursery.



White Pine Seedlings in State Nursery.

Besides the necessity for maintaining these great forest industries and increasing the forest productivity, there are other reasons why the state must take an active part in the National forestry movement. The recent report of the National Conservation Commission is conclusive evidence that the timber resources of the country are fast disappearing, and that a timber famine is imminent. This report says that the total yearly growth of our forests is less than seven billion cubic feet; while twenty-three billion cubic feet are cut, or more than three times the growth. It also says that fully fifty million acres of forest land are annually burned over in the country. Although Vermont, on account of its small size, is the twenty-eighth state in order of their importance as timber producers, it is not less important that the state bear its share in warding off this famine.

Recent droughts, which have been so serious in some localities, indicate the advisability of maintaining a forest cover for the protection of springs and brooks. Although there is little evidence that forests actually affect rainfall, their value for holding the snow in spring and thus preventing floods, and for retaining moisture in the soil, is a well established fact.

II. VERMONT'S BEGINNINGS OF FORESTRY—THE STATE FORESTER'S OFFICE

The legislature of Vermont at its recent session provided for the creation of a State Board of Agriculture and Forestry, and the appointment of a State Forester. In doing this the state follows the example of Connecticut, Massachusetts and Rhode Island in New England; and of California, Indiana, Maryland, Michigan, Minnesota, New Jersey, New York, Pennsylvania and Wisconsin in other parts of the country.

Inasmuch as the first step toward the practice of forestry must be the reduction of damage by forest fires to a minimum, the most important duty of the state forester is to increase the efficiency of the warden service and inaugurate any other measures necessary for doing away with these fires. A study of the fires which occur in the state will be necessary before recommendations along these lines can be made.

American institutions are opposed to governmental regulation of private property, so the progress in forestry must be along two lines,—

(1) Administration of lands owned by Nation and State.

(2) Instruction of land owners in the methods, purposes and advantages of practicing forestry.

All of the National forests, comprising an area of about 190,000,000 acres, are west of the Mississippi River. While it is possible that the government may be warranted in purchasing certain forest tracts in the East, it is probable that no such need will arise in Vermont. The state has too proud a history to ask for National assistance in dealing with a problem which it is itself able to handle.

In this same enactment, the General Assembly made provision for the purchase of state forests. The present appropriation makes an immediate beginning in this line possible; and it is probable that considerable areas, especially in the Green Mountains, will in time be acquired and managed by the State. The purpose of these tracts is primarily to raise valuable timber, but it will also be educational, insofar as they afford examples of good forestry for the benefit of such as visit them. There are probably many land owners in the state who would be interested in having their land managed under forestry principles, but are not in a position to carry out this wish themselves. It is hoped that many such owners will donate tracts to the state to be managed as permanent memorials of their families or friends. Any owner contemplating such a donation may inquire concerning its disposition, either addressing J. L. Hills, Secretary of the State Board, or A. F. Hawes, State Forester, Burlington, Vt.

Next in importance to the prevention of forest fires, is the education of land owners so that they may carry out forestry principles on their own land. As already pointed out, the example furnished by the state forests will be the most effective means of bringing this about.

Investigations and experiments will be made by this office to obtain accurate information about the various forestry problems of the state, and the results will be published from time to time. In the meantime the state forester will be glad to meet granges and other organizations and to explain the purposes and results of forestry methods. He is prepared to give illustrated lectures when desired. Applications for talks should be sent in at least three weeks in advance of the desired time, so that if possible arrangements can be made to give several talks on a trip. Correspondence is especially invited on all forestry topics.

Interest in forest planting has grown so much during the past few years, and our nursery companies have done so little to meet the growing demand for stock, that it has become imperative to find a supply of material for land owners if there is any expectation that they will carry out the recommendations for planting. Until the nurseries make some such adequate provisions at reasonable prices, this office will act either as broker for the farmer, purchasing the stock at wholesale rates and selling at the same prices; or as nurseryman. The state already has a well established nursery. This will be enlarged at once, with the hope of supplying in a few years a large amount of material. In the meantime the aim of the office will be rather to furnish small orders to a large number, so that every land owner may become interested by the time a large supply is available.

III. INSTRUCTIONS REGARDING FOREST PLANTING

Bulletins 120, 127 and 132 of the Station, available on request, give a full account of the advisable methods of forest planting. the state.

The species which can be recommended are: Three species of pine, the white, scotch, and red or Norway; the Norway spruce and European larch;; and of the deciduous trees, the white ash and the black locust in the lower altitudes, and chestnut in the southern portion of the state.

The white pine is native throughout the state, and is the most valuable tree in New England. It grows rapidly and produces dense stands. The following figures give the results of measurements of several white pine plantations in Connecticut, where the conditions are less favorable than in Southern Vermont.

Name	Age, years	Approximate area, acres	Number of live trees per acre	Total yield per acre, Feet, B. M.	Mean annual growth, Feet, B. M.	Value stands per acre
Greenfield Hill	22	10	1,312	12,280	558	$ 61.50
Shakers	31	100	1,164	15,052	486	75.25
Windsor	50	8	276	41,720	834	291.70
Davis	70	4	524	60,360	862	422.80

The Scotch pine can be especially recommended on account of its very rapid growth as a young tree. On the poorest soils it makes a remarkable showing in a few years. It is also free from the attacks of the pine weevil, which injures the white pine.

The Norway or red pine is a native of Vermont. Its rate of growth is about the same as that of the white pine, and it is also free from the attacks of the pine weevil. While the lumber is slightly inferior to that of white pine, it should be widely planted as soon as there is a supply of seedlings available.

Norway spruce should not be planted so much on the sandy land as in situations with a somewhat heavier soil. It is more rapid growing than our native spruce, and apparently the lumber is equally good.

The European larch differs from our native tamarack in being a tree of the uplands rather than of the swamps. It can be recommended for planting where the soil has a fair mixture of loam, and is especially recommended for southern slopes.

Forest planting in the northern part of the state should be wholly with conifers. But in the southern part the chestnut may be profitably planted where the soil is fairly good and not too dry; and the white ash in still moister and cooler situations. There is now a chestnut disease working in New York and Connecticut which threatens to do considerable damage, and until more is known about it planting should be on a small scale.

The black or yellow locust may be planted on soils too poor for the ash and chestnut. It is a rapid grower, and the wood is valuable for its lasting qualities. Unfortunately it is often damaged by a boring insect.

SEEDING AND PLANTING

Experience in this country as well as abroad has shown that planting is much preferable to seeding. Satisfactory results can never be obtained from sowing tree seeds on unprepared land. If the land is free from rocks, so that it can be plowed and harrowed, by the application of a considerable supply of seed a stand can be secured. Other methods are:—To plow furrows every six feet, or to stir up the soil every six feet with a mattock or hoe. However, the forest resulting from any method of seeding is irregular, is three or four years behind a planted forest of the same age, and is practically as expensive to make as is a successful plantation.

CHARACTER OF STOCK ADVISED

While woods-grown seedlings can sometimes be secured cheaper than nursery stock, they are much less satisfactory. Grown in the woods, their root systems and light foliage are poorly adapted for transplanting, so that many of them die.

For the pines, three year old nursery stock gives the best results. This may be either of seedlings which have remained in the seed bed three years, or which were transplanted into nursery rows at the end of their first or second year, in which case they are called transplants. Two year seedlings or transplants can only be used on land which is free from brush or strong grass growth. As it takes them two or three years longer to start growth than the older stock, they are less satisfactory.

For the Norway spruce three or four year old stock should be used, preferably four year transplants.

For European larch, two year stock is preferable.

For chestnut, one or two year seedlings should be used.

For white ash, stock two to four feet high should be used.

For black locust, one year seedlings should be used, as older material is difficult to transplant.

SOURCE OF SUPPLY

Where a land owner contemplates planting over one hundred acres of land, it may be cheaper for him to raise his own nursery stock. The chief disadvantage in this is that the time of final planting must be postponed two or three years. This office will be glad to instruct any who wish to establish private nurseries.

There are several nursery companies in America which raise seedlings of the above species, but up to the present time they have raised them on rather a limited scale, chiefly for ornamental purposes, and consequently they have been too expensive for forest planting investments.

In order to furnish such a supply, the legislature made two years ago an annual appropriation of five hundred dollars for nursery purposes. A large supply of stock was sold to land owners last spring. The material now on hand is as follows:—

		Cost per M.
White pine 2 yr. seedlings......	30,000	$3.50
White pine 4 yr. transplants......	6,000	
Scotch pine 2 yr. seedlings	27,500	4.00
Scotch pine 4 yr. transplants.....	1,000	
Red pine 3 yr. transplants........	4,000	
Norway spruce 2 yr. seedlings....	1,500	
Norway spruce 3 yr. transplants..	1,000	
Arborvitae 3 yr. transplants......	1,000	
	72,000	

The material for which a price is given is ready for distribution; the remainder is reserved for use on state lands.

The nursery also has 400,000 one year seedlings, some of which will be ready for distribution next year. It will be much enlarged this year, so as to provide a large amount of stock for future years. As there is no available supply of three year old native stock, we have secured from a German nursery two hundred thousand three year transplants of white pine which will be for sale to land owners at cost price. The cost of these trees at the nursery is $2.00 per M; but as there is a duty of $1.00 and 15 percent ad valorem, and the freight and packing charges must also be added, the final cost will probably be between four and five dollars per M. We have also secured from nurserymen 15,000 three year old Norway spruce which will be sold at $7.00 per M. Written orders for any of this material will be considered in the order in which they are received. Not more than 20,000 trees can be supplied to any one land owner, and orders for less than 500 will not be considered. Orders may be addressed:—A. F. Hawes, State Forester, Burlington, Vt.

TIME OF PLANTING

The best time for planting is as early in the spring as possible after the frost is out of the ground. This will be from the middle of April to the middle of May, although the season may safely be extended until the first of June in the case of the pines. No trees should be transplanted during the growing season.

NUMBER OF TREES PER ACRE

The number of trees which should be planted on an acre depends somewhat on the purposes of the plantation and the kind of land. On the poorer soils more trees should be planted than on good soils; and for clear lumber more trees should be planted than for box boards. Close planting brings about an early pruning of the lower limbs, and forces the trees up to get light from above.

For an average plantation 1,500 trees per acre is the best number. This is equivalent to a spacing of five by six feet.

METHOD OF PLANTING AND COST

Planting has been done on a large scale on the state land in Union, Conn., for $8.70 an acre, including labor and a charge for trees of $3.75 per thousand. On the arrival of the trees from a distance they should at once be heeled in near the place of planting, preferably in a shaded, well-drained situation. Not more than five hundred trees should be taken out at one time for a crew of three planters. The bundles should be untied and the roots puddled in a thick mud. They should be protected in the basket with wet moss or cloths, and the roots should never be exposed to the air for a minute. A still, cloudy day early in spring when the ground is moist is most suitable for planting.

The method of planting found to be most efficient and economical is with crews of four men. Three men work abreast with mattocks, keeping straight lines by sighting on poles placed six feet apart at the other end of the field. One man or boy carries a basket with the trees and hands them to the planters as they are required. The sod should be somewhat scraped away by the mattock. The mattock is then struck down into the earth, the handle is raised and somewhat twisted, making a small hole just large enough for the little tree. The earth is then pressed firmly about the roots with the foot, the mattock not being removed until the tree is set. A crew of four men in open pasture free from brush and stones can plant 4,000 trees a day without much trouble. In very stony or brushy land they may not plant over 2,000. It pays to hire good men at high wages for this work, as for everything else. The secret of the cheapness of the planting at Union is that nearly all the labor was done by native Americans who were interested in the work.

What is said here regarding methods of planting pine applies equally well to the other species.

FORESTRY

SUMMARY BULLETIN 139

1. The three important lines of work in forestry are the planting of forests, the improvement of existing forests, and the careful harvesting of mature forests.

2. Forestry must be in the future an important part of the business of the Vermont lumbermen, farmers, and other private and corporate owners of land.

3. The State of Vermont is very largely dependent upon forest industries; and already the amount of the lumber business has begun to diminish.

4. The prevention of forest fires must be the first step toward the bringing about of better forest management.

5. Forestry work in Vermont must be largely by private owners, and this must be brought about by educational rather than by coercive means. The object of the state forester's office is largely to serve as a center for this educational work.

6. State forests are essential for the raising of large dimension timber, as examples to private owners of the best forest methods, and because experience of other nations has shown that private forest management must always be supplemented by state management. It is hoped that several forest tracts will be donated to the state.

7. The species advised for planting in Vermont are the White, Scotch and Norway or Red pines; Norway spruce, European larch; and to a limited extent white ash, chestnut, and black locust.

8. Nursery stock for this spring's planting can be secured in limited quantity from the state forester's office.

A. F. HAWES, State Forester.

UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL
EXPERIMENT STATION
BURLINGTON, VT.

BULLETIN NO. 157
MARCH, 1911

The Damping Off of Coniferous Seedlings.

BURLINGTON:
FREE PRESS PRINTING COMPANY,
1911.

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*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

BULLETIN 157. THE DAMPING OFF OF CONIFEROUS SEEDLINGS

C. M. GIFFORD.[1]

SUMMARY

I. Several species of coniferous seedlings commonly grown in nurseries, viz.: white pine (Pinus strobus), Scotch pine (P. sylvestris), yellow pine (P. ponderosa), Norway spruce (Picea excelsa) and European larch (Larix decidua), are subject under unfavorable conditions to severe attacks of "damping off."

II. The damage may range from almost nothing to 90 percent of the stand, it being increased by warm weather following germination, by too much shading of beds, and by an alkaline reaction of the soil.

III. This damping off is caused by a fungus of the genus Fusarium.

IV. This fungus appears to be native to this country and very widely distributed.

V. The fungus has been repeatedly isolated from the roots of two-year-old seedlings of white pine, which showed in the beds a progressive dying, in some cases the bed being practically ruined.

VI. The fungus grows readily on all the varieties of cultural media used. It fruits abundantly, producing three kinds of spores.

VII. The spores first produced are called microconidia.

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[1] The work upon which this bulletin is based was done by the late C. M. Gifford. His senior thesis, a prerequisite for graduation from the agricultural department of the university, dealt with this malady; and during the past summer he continued his studies thereon. Before his departure for a position at the West Virginia Station, he collected his data and wrote up the subject essentially in the way it is now presented. After Mr. Gifford's death, by drowning in mid-December, the task of preparing his manuscript for publication fell upon the writer of this note. The changes made by the editor are only minor ones and involve more the manner of presentation than they do the subject matter itself.

B. F. LUTMAN.

They are of an elongated oval shape, often slightly curved, and usually become two celled. The macroconidia are the characteristic Fusarium spores, from two to three times longer than broad, more or less pointed at the ends and curved and from two to five times septate. The chlamydospores are spherical in shape, produced rather sparingly, and usually under adverse conditions.

VIII. The sterilization of the soil by the use of live steam did not give results warranting its general adoption. It lessens the amount of moisture in the upper layers of soil, probably by diminishing the power of the soil to draw up moisture from below by capillarity.

IX. The best preventive measure seems to be the disinfection of the soil by the use of a one-half to one percent solution of formalin, used at the rate of the three-fourths of a gallon per square foot. Afer treatment the bed should be allowed to air for at least a week before sowing the seed.

INTRODUCTION

With the present widespread interest in forestry and in methods of forestry reproduction has come so large a demand for seedlings for forest planting that the commercial nurseries have been unable to meet it. Furthermore these nurseries have quoted relatively high prices. Hence the establishment of state nurseries in several states which furnish seedlings for forest planting to landowners at, as nearly as may be, the cost of production.

The first seed beds in the Vermont State Nursery were sown in 1907. One of the problems with which the new nursery had to deal, almost from the first, was the disease known as "damping off" of the young white pine seedlings. When the weather conditions were favorable to its spread, it often caused serious damage, hence methods for combating it were sought. During the summer of 1907, Mr. F. V. Rand of the class of 1908 isolated the fungus causing the malady, and determined the value of various chemicals for the disinfection of the soil. This was done under the general direction of, and in cooperation with, Dr. Perley Spaulding of the Bureau of Plant Industry. During the summer of 1908 further work on soil disinfection was carried on by the station. In the spring of 1909, a study of the disease and of the fungus causing it was suggested by the station botanist (Prof. L. R. Jones) to the writer as a topic for senior thesis. The work was begun in the latter part of June, carried on during the summer as a part of the field work of the station, and prosecuted throughout the past college year with the council of the then station botanist and bacteriologist (Profs. L. R. Jones and H. A. Edson).

REVIEW OF LITERATURE

In 1892 Hartig (3)[1] described a disease very similar to the one present in the Vermont seed beds, which sometimes did much damage to pine and spruce in the Bavarian nurseries. He thought the fungus to be a Nectria, but in a later writing called it *Fusoma parasiticum.* As a remedial measure he recommended diminishing the surplus moisture by removing shade. If old beds were to be used, he advised sterilizing the soil by firing for two days.

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[1] Numbers in parenthesis refer to bibliography, p. 171.

In an earlier publication of this station, Jones (5) advanced the opinion that the Fusarium-like fungus was of widespread occurrence, and a native, rather than an introduced, species. He stated that the development of the disease seemed to depend upon conditions of temperature and moisture in the beds, the previous treatment of the soil, which may tend to increase or diminish its fungus content, and the use of fungicides or other substances upon the beds during the critical period. He found that disinfection of the soil with a dilute solution of formalin before sowing, lessened the seed germination from 25 to 50 percent but also lessened the damage from damping off from 90 percent in the untreated beds to 9 percent in the treated. He also recommended the practice of sprinkling the beds with hot sand.

Pollock (7) found that the damping off in soil secured from the government nurseries at Halsted, Nebraska, was caused by a Fusarium. After the seedlings damped off in his pots they were allowed to stand for seventy-five days from the time of the planting the seed, when the ascus fruit of a Nectria was observed scattered over the surface of the soil, though never on the decaying plants. It was found to be similar both to *Nectria thuyana,* found by Ellis on *Cupressus,* and also to *N. indigens* found on rocks in the Alps.

Hartley (4) finds in these same seed beds a Fusarium, a Rhizoctonia, and a Pythium, probably *P. de Baryanum,* all capable of causing damping off, but the last named the most destructive, with the Fusarium next. He states that the drying out of the surface moisture increased the damping off, giving as a possible explanation the theory that drouth weakens the plants and so predisposes them to attack.

Occurrence of the Disease

As noted previously, Hartig (3) described what appears to be the same fungus attacking pine and spruce in the German nurseries. It was found in June, 1907, on seedlings of white pine from the New York state nursery at Saranac Inn. Hartley (4) reports a Fusarium as causing a damping off in the government nurseries at Halsted, Nebraska. In August, 1909, diseased seedlings of white pine (*Pinus strobus*), Scotch pine (*P. sylvestris*), yellow pine (*P. ponderosa*), Norway spruce (*Picea excelsa*), from the nurseries of the Northwestern Forestry Co., at East Haven, Connecticut, were examined by the writer, and the spores (macroconidia) of a Fusarium were found upon them all. A considerable damping off was noted in the state nursery at Burlington in June, 1907, in the beds of Norway spruce, yellow pine, Scotch pine, white pine, and European larch (*Larix decidua*).

The above evidence would seem to support the statement made by Jones (5) that the fungus is of widespread occurrence, and probably native to this country rather than introduced.

Description of the Disease

The observations made by the writer confirm those of earlier students of this malady as to method of infection by the damping off fungus. This seems to take place by the tip of a fungus thread boring its way into the tender stem of the seedlings, probably dissolving a portion of the epidermis by means of the secretion of an enzym. Having gained entrance to the soft internal tissues it grows vigorously, and in a short time so weakens the stem that the seedling falls over and, its water supply being cut off, soon dies. In some cases, especially when the seedlings are in a dense stand, and the weather conditions are very favorable, the fungus seems to attack the upper portion of the stem just at the base of the cotyledons or seed-leaves. Again, it has been observed that under certain conditions the fungus may attack and kill the seedling, and the attack be so general that the seedling does not fall over, but remains standing, dry and shriveled. This was seen during the past summer in some beds of Scotch pine. At first it was thought that the death was due to other causes, perhaps a lack of moisture; but upon examining one of the seedlings under the microscope the long sickle shaped Fusarium spores, macroconidia, could be seen in great abundance. Therefore it was thought probable that the attack of the damping off fungus was largely responsible for the death of the seedlings.

FACTORS INFLUENCING THE AMOUNT OF DAMAGE

The amount of damage which may be caused by the fungus varies with the temperature and moisture conditions during the time following germination. Closely related thereto is the way in which the beds are handled. From the time of sowing until germination is completed, the beds must be covered to keep out the light and to conserve moisture. In the state nursery this is usually accomplished by means of a frame, with sides eight inches high, made of two 1x2 inch strips run parallel, the space between being covered with fine poultry netting to keep out the birds. This is covered by a frame of lath 4x12 feet, every other lath being removable, so as to give half shade after germination. At the time of sowing a strip of building paper is tacked around the sides, but is removed after germination unless the weather is extremely dry or the reverse. By means of this lath shade the amount of moisture in the surface layers of the soil can be very closely regulated.

Another factor, which seems to have an important bearing upon the amount of damage, is the reaction of the soil. At the time the state nursery was started, in the spring of 1907, a portion of the field was given a heavy dressing of lime-kiln ashes. Ever since that time the soil has been alkaline and in that portion of the nursery there has always been more loss from damping off than in the area not so treated. It has been found that with other diseases caused by fungi in the soil, as potato scab and root-rot of tobacco, an alkaline reaction greatly increases the amount of injury.

While it is possible in the case of the damping off of the pines that the alkaline reaction has the direct effect of lessening the vigor of the host plant, it seems more probable that its effect is that of increasing the virulence of the parasite. From the excellent results reported by Spaulding (9) from the use of sulphuric acid in combating the disease it would seem that the effect of an acid reaction must have been the inhibition of the growth of the fungus rather than any stimulation of the host plant. During the past two seasons (1909 and 1910) there has been but little damage in the state nursery due to damping off. The rainfall has been slight during the critical period, and the beds have been fertilized with a compost of muck and stable manure, thus tending to keep the soil reaction acid. Furthermore, the shading has been so managed as to tend to correct any weather conditions likely to cause the spread of the disease.

THE FUNGUS ON ROOTS OF OLDER SEEDLINGS

On June 25, 1909, bed 14 of the two-year old white pine was being dug up, preparatory to reseeding. The bed showed a rather uneven growth, in some places the seedlings being stunted and even entirely dead, while in other parts they looked healthy and vigorous. It had been decided to transplant those which were healthy, and reseed the bed for disinfection trials. A growth of a grayish white fungus was noted upon the smaller rootlets. Some of these seedlings thus affected were taken to the laboratory and the fungus isolated in pure culture on July 3. Other seedlings were collected from the same bed ten days later and on July 15 a fungus isolated by laying the roots on a plate of synthetic agar. The mycelium was found growing two days later, and from the cortical portion of the root, radiating in all directions. This was similar to the fungus obtained previously.

The seedlings used included both large, healthy looking ones and the smaller stunted ones. The latter when collected did not show any external growth of mycelium, due probably to the fact that they were so nearly dead.

Seedlings which showed the same appearance as those in bed 14, were taken on July 21 from beds 4, 9, and 10, of two-year old white pine. The fungus was obtained from each of these beds in the same way as in the previous case.

In bed 14 where the mycelium on the roots was first observed, some of the seedlings appeared especially large and vigorous. Samples were taken July 24 to see if they were infected by the fungus. The roots showed little or no external growth of mycelium. Seedlings were also collected from bed 20, containing one-year old Scotch pine. These seedlings appeared healthy, and showed no external growth of mycelium. Cultures prepared in the same way as previously gave the same fungus from both sources.

Nine beds of year-old white pine which were dug up on May 20 showed many seedlings betraying the same appearance as the stunted lots in the older beds. But in this case the dying seemed to be uniform and complete all over the bed. It seems probable that the root systems were so weakened by the attacks of the damping off fungus the preceding summer that the plants were unable to live through the winter. Such being the case, it was to be expected that there would be a large amount of damping off in the young Scotch pine with which the bed was replanted.

The addition of the compost, howeever, probably lessened the alkaline reaction of the soil, and the weather was rather cool and dry and unfavorable to the attacks of the disease; hence little of it appeared.

The injury to beds 4 and 14 had continually increased and consequently they were spaded up, preparatory to reseeding on July 26 and 31 respectively. Early in September most of the seedlings along the south side of bed 9 seemed to be seriously attacked. Some were entirely dead and others had made but little growth. Those in the north half appeared healthy and to have made a good growth.

All of these beds were located in the area which had received the lime-kiln ashes; (page 148). No such conditions were manifested in any of the beds at the south end of the nursery, where the soil was found to be acid. During the summer of 1910 one bed of year-old white pine at the south end showed along its south side a condition very similar to that above described. Seedlings were collected therefrom, their roots thoroughly washed, and the fungus isolated without difficulty. The bed was watched throughout the summer, but the disease did not seem to progress as it did at the north end, probably because of the acid reaction of the soil.

The genus Fusarium is not so virulently parasitic as are some fungi, and hence requires especially favorable conditions for the development of its facultative parasitism, in this case the condition being an alkaline reaction of the soil. During the past summer the Fusarium which is thought to cause the stem blight of the China aster, *Callistephus hortensis Cass.*, as noted by Duggar (1) has been reported in Vermont and seems to be very destructive wherever it gets a foothold. A Fusarium causing a similar disease of the garden pea (*Pisum sativum*) has also been found. Hence it is probable that under favorable conditions the Fusarium of damping off can attack the roots and stems of the older seedlings and sometimes even kill them.

DESCRIPTION OF THE FUNGUS

METHODS OF OBTAINING PURE CULTURES

As hitherto stated on page 145 the fungus was first obtained in pure culture at this station in June, 1907. It was isolated from seedlings of yellow pine (*Pinus ponderosa*) and carried through the summer, but unfortunately the cultures were lost. The description and drawings then made did not come into the hands of the writer until after the fungus had been again isolated, when they were found to agree closely with the later observations.

Seedlings of Scotch pine (*Pinus sylvestris*) which appeared to have damped off, were dipped in mercuric chlorid 1-1000, rinsed in sterile water and with sterile forceps dropped on a freshly poured plate of synthetic dextrose agar (Plate I, figure 2). Another method used was to cut out a piece of the stem at the point of attack, and drop it on a poured plate, as above. Some whole seedlings also were dipped in mercuric chlorid, washed in sterile water, and then placed in a moist chamber.

Plate cultures were prepared from the seedlings placed in the moist chamber, and from the plate cultures first made. These cultures all showed the characteristic Fusarium spores after ten days. Plates were poured from these, and the process continued till pure cultures were obtained.

Isolations were obtained at various times during July, 1909, from four different lots of white and Scotch pine seedlings obtained from various parts of the nursery where the beds were infected. These cultures were all carried along together and were used in the later inoculation experiments.

MYCELIUM

The mycelium shows neither on the surface of the soil nor on the seedlings which are attacked. The growth in poured plates of synthetic agar or potato agar is white and of varying degrees of density above the surface of the agar. If the spores are sown thickly, vigorous spore production takes place by the second day with little growth above the surface. If, however, the spores are few in number producing only three or four colonies on a plate, a luxuriant white mycelium becomes evident, the radiating hyphae forming a sort of rosette growth extending peripherally comparatively slowly. The mycelium is from 3 to 5 microns in diameter, septate, abundantly so where fruiting is taking place, and is well filled with oil drops.

MICROCONIDIA

The mode of formation of the microconidia was studied from thickly seeded potato agar plates. By cutting out a piece about one centimeter square, and placing it on a cover glass which was sealed over the depression in a hollow ground slide, the mount could be examined with the high power objective while fruiting went on undisturbed. The method by which the microconidia are formed in shown by figure 1. It seemed to correspond very closely to the method observed by Smith and Swingle (8) in *Fusarium oxysporum.* A lateral hypha grows out from one of the main filaments, the end swells slightly and the portion forming the microconidium is cut off by what Smith calls a "construction furrow." The microconidium lies along-side of the first, the process continuing till five or six are formed. After fruiting has gone on for sometime, the appearance under the low power objective resembles a bunch of bananas. The formation of microconidia begins in from 24 to 26 hours and lasts for about 48 hours. The size when grown in potato agar ranges from 3 to 5.3 microns in diameter, and from 9.4 to 17.8 microns in length. The most common size is about 3.5 by 12 microns. Germination takes place very readily. In potato agar (figure 2) germ tubes are put forth in from 5 to 8 hours. In distilled water several were found to be germinating at the end of an hour and half. A septum usually forms across the middle of the spore, just before or during germination.

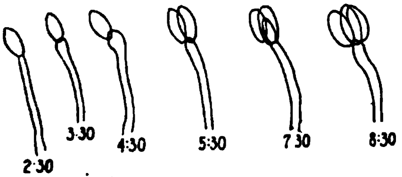

Fig. 1. Stages in the formation of microconidia of conifer Fusarium × 500.

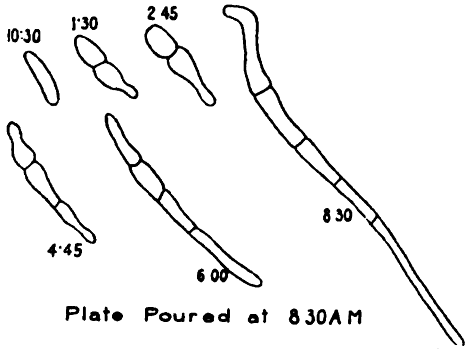

Fig. 2. Stages in the germination of a conifer Fusarium microconidium × 500.

MACROCONIDIA

It is by this type of spore that the Fusarium genus is recognized. They are produced about two days after the microconidia begin to be numerous, in older cultures being found almost to the exclusion of the former. They seem to be formed from short lateral branches above the surface of the medium, and are cut off in much the same way as the microconidia. They contain from one to five septa which appear after they have been set free from the parent branch. They are usually somewhat curved, especially toward the ends, which when grown in potato agar are not sharply pointed. In this medium the diameter was from 4.7 to 6.2 microns, and the length from 18.7 to 37.4 microns, the most common size being about 6 microns in diameter and 32 microns in length. When obtained from a diseased seedling, they were more slender and sharply pointed, and curved. Besides granular protoplasm, they usually contain oil drops. Their method of germination in hanging block cultures is shown in figure 3.

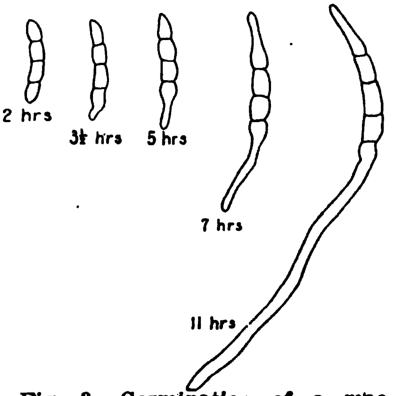

Fig. 3. Germination of a macroconidium × 250.

CHLAMYDOSPORES

The chlamydospores (figure 3) are spherical swellings of the mycelium, usually found at the ends of slender lateral hyphae, though they may be formed at any point in the hypha. They are thought to exist for the purpose of carrying the fungus through unfavorable conditions. They were first observed in some mycelium taken from a diseased seedling which had been placed in a moist chamber for two days. They were found very abun-

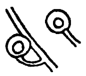

Fig. 4. Chlamydospores of conifer Fusarium × 500.

dantly in a growth of mycelium on the roots of some two-year old seedlings of white pine which had been placed in a moist chamber and after the mycelium had developed had been left until they dried. They were found in plate cultures where bacteria were numerous during the process of isolation of the fungus. On examining plate cultures up to a month old, chlamydospores were found fully developed in those 16 days old or older, the early stages being found in cultures 9 days old.

GROWTH IN DIFFERENT MEDIA

The fungus was grown in several different kinds of culture media, for the purpose of noting their effect upon its habit of growth, and with the possibility in mind of the discovery of the occurrence of the perfect stage in some medium not commonly used.

Synthetic dextrose agar. Growth rather dense, white, several millimeters high. In older cultures, surface of medium very much wrinkled and contorted.

Potato agar. Growth more rapid and luxuriant than above. At the point of inoculation in cultures two weeks old the macroconidia pile up in a cream-colored mass. Color white to cream-colored in older cultures.

Boiled rice. Mycelium at first white, but later lavender and salmon colored in spots. In darkness, mycelium on surface remains white.

Corn meal. Growth less rapid than on potato agar, but moderately dense. Mycelium white to grayish white in old cultures. In cultures two months old, small pustules about 2 mm. in diameter and 3 mm. in length were pushed out from the sides of the medium where it had dried away from the tube. When examined, they appeared to be made up mostly of macroconidia.

Boiled potato. Growth vigorous, completely covering cylinder at end of 11 days. At end of six weeks macroconidia would be piled up in grayish brown masses in different parts of the culture. No sclerotia were found as noted by Smith (8).

Lima bean agar. Growth even more vigorous than on potato agar. At end of 4 days a dense white growth completely covered the slant surface of 1.5 inches.

FIELD EXPERIMENTS WITH REFERENCE TO PREVENTIVE MEASURES

The work done during the summer of 1909 was with a view to testing out more fully the value of formalin in preventing damping off, and its effect upon germination of the white pine in the beds. It was also planned to determine the value of steam sterilization.

The trials were made in the north end of the state nursery. The land had been previously used as a vegetable and fruit garden and the first beds were sown in the spring of 1907. The soil is a sandy loam, containing considerable more humus than that at the south end of the nursery. At this time the land was given a dressing of lime-kiln ashes at the rate of fifty bushels per acre.

DISINFECTION WITH FORMALIN

Spaulding (9) in work of this sort obtained best results with dilute solutions of sulphuric acid, using one ounce of acid to one gallon of water. His results from the use of formalin at the rate of 4 ounces to 3 gallons of water were poor, in some cases the untreated plot being better. However, this may be explained by the fact that the seed was covered with untreated soil, while in the trials now under survey the soil used for covering was soaked over night in formalin solution and then dried before use.

The first trial was a simple test of formalin disinfection. On May 20 nine of the beds which had contained one-year-old white pine seedlings were dug up and eight of them sown to Scotch pine. It was thought at the time that the plants had been simply winter killed, but later development in neighboring beds pointed to the probability that death was in part due to the attacks of the damping off fungus on the roots.

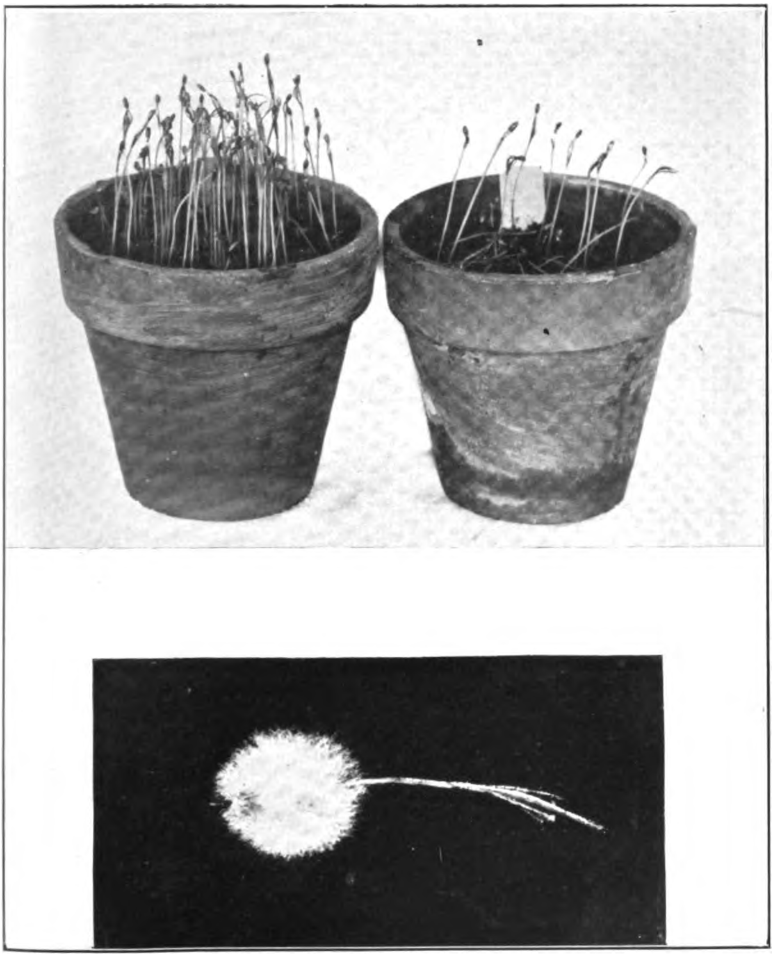

PLATE I. Figure 1. Pot grown seedlings of Scotch pine. Pot on left, sterilized; pot on right, unsterilized.

Figure 2. The mycelium (48 hours old) growing from a diseased seedling placed on a plate of synthetic agar.

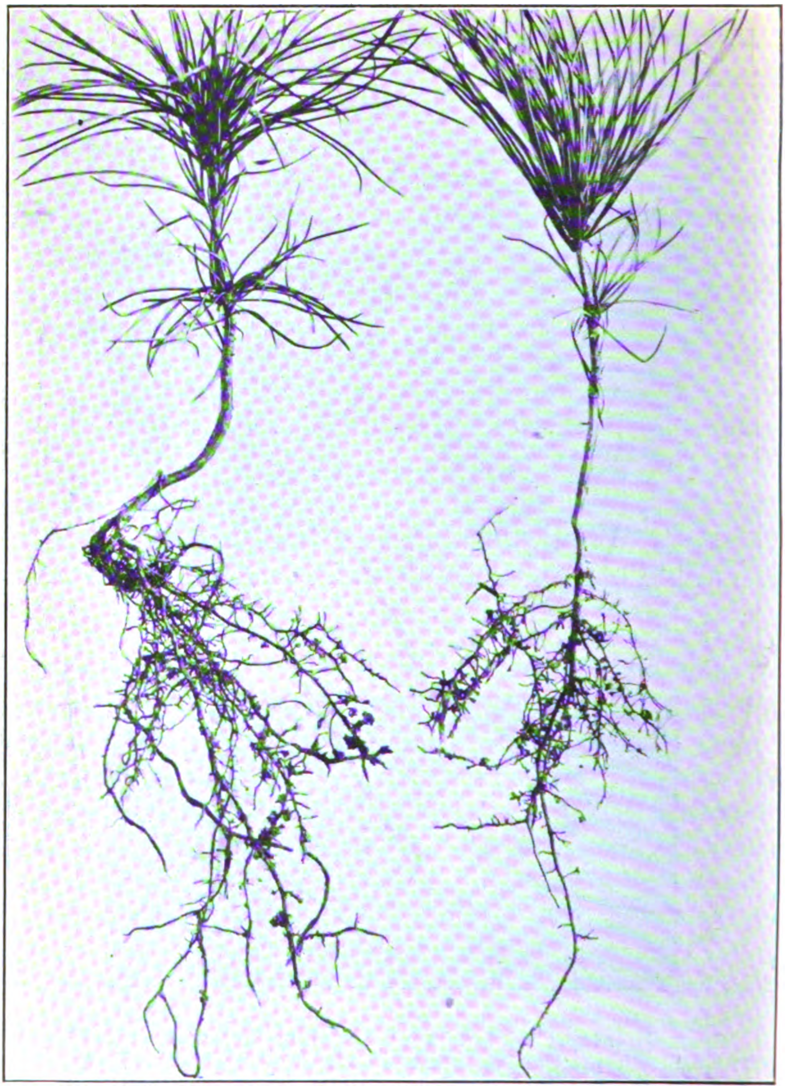

PLATE II. Two-year-old seedlings of white pine, showing abundant mycelial development on the roots. Note the swollen appearance of many of the rootlets.

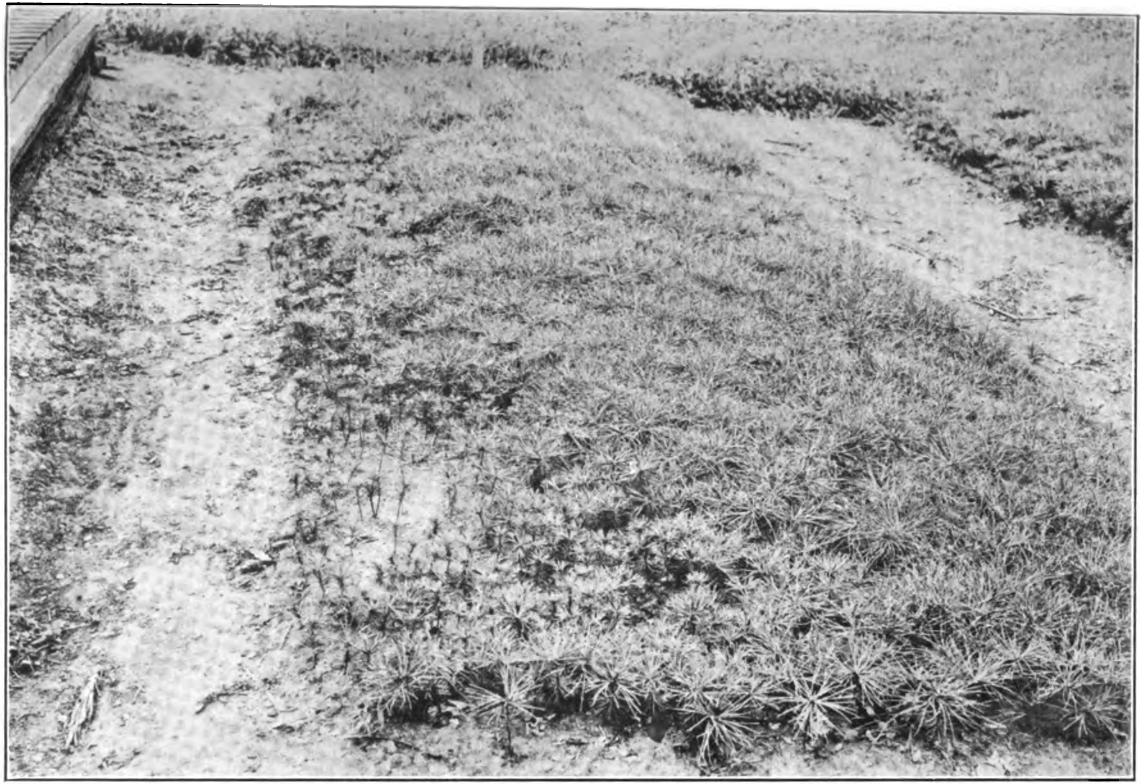

PLATE III. Bed of two-year-old white pine seedlings showing dying on one side of bed, due to damping off fungus.

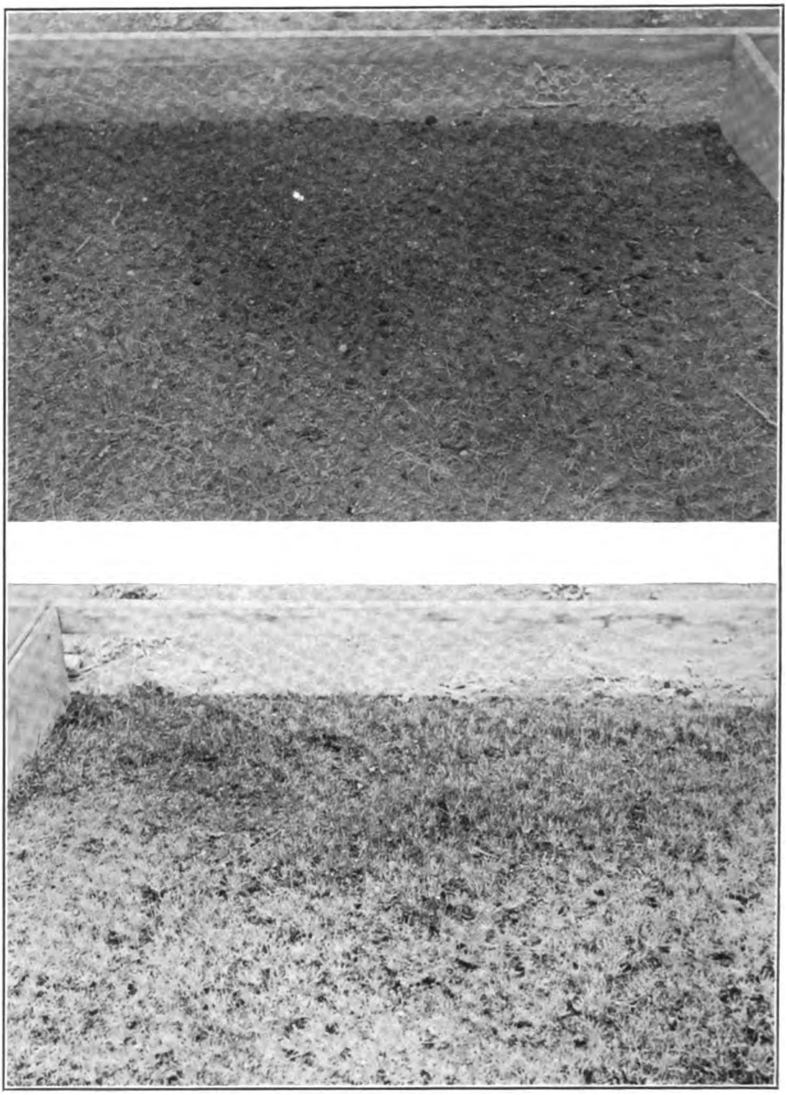

PLATE IV. Figure 1. Untreated portion of bed of white pine seedlings, ten days after sowing. Figure 2. Treated portion (1% formalin) of similar bed.

On June 26 the ninth bed was spaded up and a wheelbarrow load of manure and muck compost thoroughly worked into the soil. The bed was then divided by board cross partitions into three equal parts and the middle one of these divided by a lengthwise partition into two equal parts, (figure 5). Formalin solution was then applied to two-thirds of the bed at the rate of 1½ gallons per square foot. The solution used on part 1 was made by adding one part of commercial formalin (40 percent formaldehyde gas in water) to 100 parts of water or a one percent solution. Part 2 received a three-fourths percent solution and part 3 a one-half percent solution. No water was added to the control. One-third of the formalin solution was added late in the afternoon of the 26th and the remainder on the morning of the 27th. The bed was enclosed by means of the building paper and the lath shades described on page 148, the latter being removed at the end of forty-eight hours.

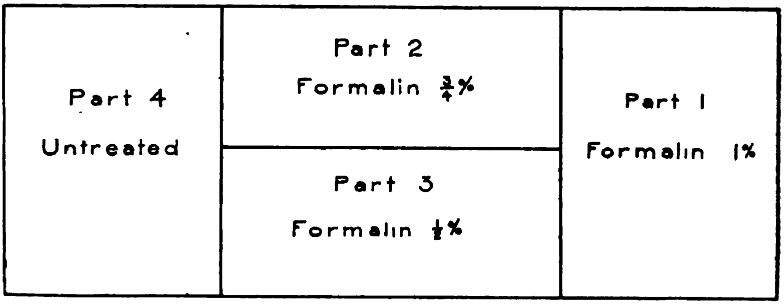

Fig. 5. Plan of bed used for formalin disinfection.

On the afternoon of July 8, the bed was sown with 10 ounces of Scotch pine seed. The seed on parts 1-3 was covered with soil which had been disinfected by soaking over night in one-half percent formalin. The lath shades were again placed on the bed and left till germination was well under way.

On July 27 damping off had begun as shown by the following table:

Part.	Treatment.	No. of seedlings attacked.
1	1 percent formalin	13
2	¾ percent formalin	4
3	½ percent formalin	3
4	Control	50

On August 1, the disease had progressed considerably in the control, but showed little in the treated portions. Three days later about one-half of the seedlings in part 4 were attacked, while the other parts showed very little injury. From this time on, the disease continued to increase in the control until the 18th, when it was estimated that more than three-fourths were attacked, (see plate IV). At this time the disease seems to have nearly reached its height, for on the 24th its progress seems to stop, leaving the stand in the control perhaps one-tenth as good as that in the treated portions where the seedlings completely covered the ground.

The results of this trial show very clearly how serviceable formalin is when used on soil known to be infected with the damping off fungus.

LENGTH OF EXPOSURE AFTER USING FORMALIN

One of the objections to the formalin treatment is that it sometimes reduces the percentage of germination. In order to determine, if possible, the length of time it is necessary to leave the beds exposed after disinfection with formalin, in order to secure maximum germination from the white pine seeds, the following experiment was devised:

After being prepared for sowing in the usual way, a bed was divided lengthwise by a board partition into two equal parts. Each of these was then divided crosswise into four equal parts, making eight sections each 2x3 feet in size, (figure 6). Then one percent formalin solution was applied at the rate of one gallon per square foot to the entire half (A) of the bed, and the same amount of water to the other (B). The bed was covered with the complete lath shades and left for nearly 48 hours. At the end of that time about 7 quarts of water were applied to parts 1a and 1b, and these were each sown with one and one-fourth ounces of Scotch pine seed. The seed on 1a was covered wih disinfected soil, and on 1b with untreated soil. This portion of the bed was left covered, and the loose lath were removed from the other three-fourths of the bed.

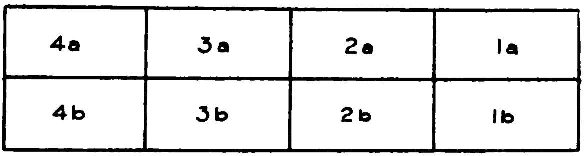

Fig. 6. Plan of bed used in determining length of exposure after using formalin before sowing.

Two days later, parts 2a and 2b were sown in the same way and left covered. Parts 3a and 3b were sown on the 6th and parts 4a and 4b on the 10th. Thus it will be seen that 1a and 1b had no exposure after the bed was uncovered; 2a and 2b two days; 3a and 3b four days; and 4a and 4b eight days. Excepting for the use of formalin the two halves, a and b, received exactly the same treatment.

The seedlings in the "b" parts came up slightly ahead of those in the "a" parts, and a marked difference in size could be seen for a few days; but the latter soon caught up. There was considerable damping off in parts 1a and 2a, but there was far more in 1b and 2b, where considerably more than one-half the stand was killed. About one-third were attacked in 3b and one-fourth in 4b. Very little occurred in 3a and 4a. Three weeks later the total number of seedlings in a strip three inches wide was counted across each section except 1b and 2b where the number of damped off seedlings was so great that it could not be determined. The figures are given in the following table:

Part.	Number of seedlings.	Part.	No. of seedlings.
1a	214		
2a	194		
3a	177	3b	206
4a	168	4b	189

These figures show that the formalin reduced the percent of germination; but in no case does this reduction exceed 14 percent, while the loss from damping off in this case ranged from 25 percent to 75 percent and has been known to reach 90 percent. There seemed to be no great diversity in results which could be attributed to the different lengths of exposure before seeding, but in general, it would seem that a week would not be too long a period to elapse between treatment and seed sowing.

STEAM STERILIZATION

The sterilization of the soil by the use of live steam has been rather widely advocated for killing undesirable soil organisms. It has been used with special success in the treatment of tobacco beds for root-rot (*Thielavia basicola*). Gilbert (2) states that its advantage over the use of formalin consists in killing weed seeds, altering the physical texture of the soil making it more suitable for root development, and rendering considerable plant food dirctly available to the seedlings.

Lyon and Bizzell (6) found that steaming soil under pressure reduced nitrates to nitrites and to ammonia, and that the ammonification and nitrification processes were practically nonexistent during the three months following steaming. In their experiments steaming appeared so to loosen the soil, that when water was applied most of it percolated to the bottom of the pot, leaving the upper soil somewhat dry. At first wheat plants did not thrive as well in the steamed soil, but after a time they began to improve and made eventually a much more luxuriant growth than did those on the unsteamed soil.

The method of steam sterilization recommended by Gilbert is called the inverted-pan method. With some slight changes to meet the conditions encountered it was used in the trials now under survey.

Bed 17 was spaded up on July 5 and prepared for sowing in the usual way, except that the frame was not put in position. The bed was divided by crosswise partitions into three equal parts (figure 7) the next day and one-half percent formalin solution was applied to part 2, at the rate of one-half gallon per square foot and the same amount of water to part 3. The bed was left uncovered. Two days later part 1 was steamed by use of a portable boiler. A galvanized iron pan, four and one-half feet square and eight inches deep was inserted over the bed, the edge being sunken into the soil to a depth of four inches. A thermometer was inserted horizontally under one corner. Raw potatoes were buried at depths of one, two and three inches before placing the pan in position.

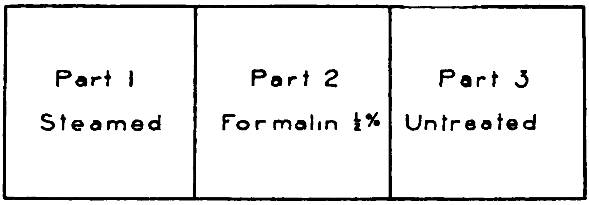

Fig. 7. Plan of bed used in steam sterilization of soil test.

When the pressure of steam in the boiler had reached 80 pounds, the valve leading to the pan was opened, and 27 minutes later the thermometer registered 201° F. The temperature remained at or near that point for half an hour, when it was found necessary to shut off the steam as the boiler was nearly empty. When the pan was removed six hours later, the potatoes were found to be thoroughly cooked.

The bed was then prepared and sown in the usual way using Scotch pine seed, which, in the treated parts, was covered with disinfected soil, and in the control with untreated soil.

Germination in the steamed part was a little slower than that in the other two parts, probably because of a lessened amount of moisture. The number of seedlings attacked on July 29 in the different parts was as follows:

Part.	Treatment.	Number attacked.
1	Steam	143
2	Formalin	105
3	Control	260

On this date was noted for the first time a difference in the amount of surface moisture in the different parts. Part 1 was dry over about five-sixths of its area, part 2 over nearly one-half, while part 3 appeared uniformly moist. This difference could be seen for several weeks, except for a short period following a rain.

From July 29 to August 3 the disease spread with great rapidity, and on the latter date the diseased seedlings were removed and either counted or estimated. The results are given below:

Part.	Treatment.	Number attacked.
1	Steam	1000
2	Formalin	579
3	Control	2000

The damping off continued to increase in parts 1 and 3, but there was little further damage in part 2. The loss in the steamed area was estimated two weeks later at 33 percent, in the formalined area at 10 percent, and in the untreated area about 50 percent of the total stand. The progress of the disease seemed to be stayed by the last week in the month.

SECOND TRIAL OF STEAM STERILIZATION

A bed was prepared on July 26 for sowing in the usual way. It was then divided by two crosswise partitions into three equal parts, and the middle one of these divided by a lengthwise partition (figure 8).

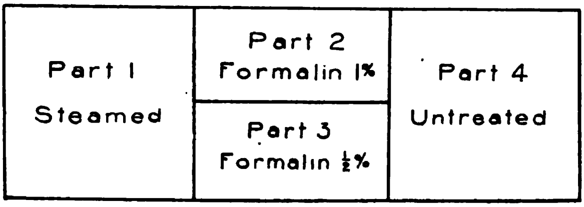

Fig. 8. Plan of bed used in comparing effects of formalin and steam sterilization on damping off.

Formalin solution was then applied to parts 2 and 3 at the rate of three-fourths of a gallon to the square foot. On part 2 a 1 percent solution was used, and on part 3 a ½ percent solution, an equal amount of water being applied to part 4.

Two days later the galvanized pan was placed over part 1 and steam passed in for an hour. The temperature, as registered by a thermometer placed under one corner was at, or near 212° F, for a period of forty-six minutes. The pan was removed after 48 hours and the bed sown in the usual way, with Scotch pine, the frame and tools having been washed with ½ percent formalin.

Germination was well started by August 25, but was progressing more rapidly in part 4 than in the other parts, especially part 1. This appeared to be due to a difference in the moisture content, as was observed in the previous experiment. This was especially noticeable after the extra shading had been removed, the surface of part 1 being uniformly dry, while that of part 4 was uniformly moist.

Damping off appeared in all parts, but was worst in part 4, part 1 being next. There was almost no loss in parts 2 and 3. Weather conditions at this time did not appear to be favorable to the development of the disease, for the loss in part 4 did not exceed 10 percent. A slight amount of injury was noted up to October 1, but more in part 4 than in part 1.

The results of these experiments would indicate:

1. That sterilization of the soil by the use of live steam is less effective in preventing the attacks of the damping off fungus than is disinfection of the soil by the use of a dilute solution of formalin.

2. That steaming lessens the amount of capillary moisture in the upper layers of soil.

The greater efficiency of the formalin treatment may be due to the fact that it leaves the soil less receptive to later infection than does steaming. In a steamed soil nearly all micro-organisms are killed and the first fungus which is introduced has an excellent opportunity for growth. Under ordinary nursery conditions it is almost impossible to prevent the introduction of the spores of the damping off Fusarium after disinfection. Hence the method which not only kills or stops the growth of the fungus already in the soil, but also leaves the soil in a better condition to withstand its later introduction, is the method to be recommended. The slight value which steaming seems to have had may very likely be traceable to its effect in lessening the amount of surface moisture, fully as much as to its value in killing the fungus previously present in the soil.

THE EFFECT OF STEAM STERILIZATION UPON THE MOISTURE RELATIONS OF THE SOIL

The effect of steaming upon the moisture content of the surface soil caused so much speculation that a simple trial was made to determine the effect of steaming upon soil capillarity.

A quantity of air-dry soil taken from the nursery where the sterilization trials were held, was heated in the autoclave for 45 minutes at 100° C. Two heavy glass tubes about six feet long and one inch in diameter were then filled with the soil, tube No. 1 being left loose, and No. 2 being slightly compacted by shaking. In the same way No. 3 and 4 were filled with the same soil, unsteamed. Pieces of cheese cloth were tied over the lower ends of the tubes, which were set in a shallow dish, containing about an inch of water. The height to which water rose was noted for intervals for a period of two months.

From the outset the rise in the unsteamed soil was much more rapid, the water column averaging about twice as high as in the steamed soil. The platted curve (figure 9) shows the height and rapidity of rise in the two kinds of soil. At the end of 63 days the heights in centimeters in the four tubes were as follows:

No. 1	35.
No. 2	29.8
No. 3	75.
No. 4	79.5

At first sight the effect of steaming might be thought to be desirable, since it induces physical conditions unfavorable to the development of the fungus. A supply of moisture in the surface layers of soil is essential, however, to good germination and to healthy growth. In fact, Hartley (4) states that the drying

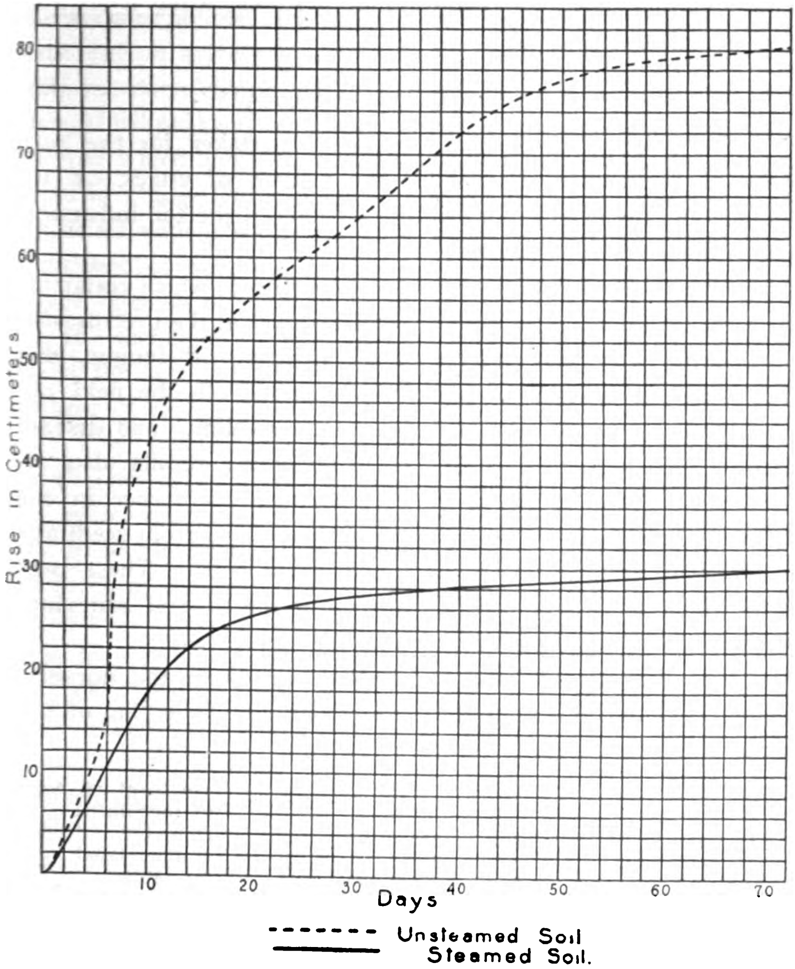

Fig. 9. Curve showing rise of water in steamed and unsteamed soil.

out of the surface moisture *increased* the damping off. This, however, has not been the case under the conditions of the trials now under survey. The effect of steaming on the moisture relations of soil should be borne in mind by those using it in general greenhouse practise.

INOCULATION EXPERIMENTS

The inoculation experiments were undertaken for the purpose of determining if possible the method of attack of the fungus and the extent to which the reaction of the soil influences the virulence of the disease.

From a number of preliminary experiments which consisted in growing seedlings in pots of sterilized soil in the greenhouse, inoculating with pure culture of the damping off fungus, and recording the amount of loss from damping off, the field observations as to the relation between soil alkalinity and disease development were confirmed. Incidentally the results also indicated that the fungus is of very common occurrence in the greenhouse soil, for it was several times isolated from seedlings which had damped off in the uninoculated pots. These pots were thought to have become infected at the time of watering, or by insects crawling over them.

The soil used in the experiment was from the nursery, sandy in character and slightly acid to litmus. The plan of the experiment was as follows:

Pots no.	Treatment of soil.	Treatment of pots.
1—2	Reaction unchanged	Not inoculated
3—5	Reaction unchanged	Inoculated
6—7	Plus 4 grs. hardwood ashes	Not inoculated
8—10	Plus 4 grs. hardwood ashes	Inoculated
11—12	Plus 8 grs. hardwood ashes	Not inoculated
13—15	Plus 8 grs. hardwood ashes	Not inoculated
16—17	Plus ½ cc. sulphuric acid sp. gr. 1.82	Not inoculated
18—20	Plus ½ cc. sulphuric acid sp. gr. 1.82	Inoculated

After the pots were filled with the various mixtures of soil, a piece of wrapping paper was tied over the top of each one, and they were sterilized in the autoclave for 1½ hours at 120° C. The seed was soaked for 10 minutes in a 1-1000 solution of mercuric chlorid, rinsed in sterile water, and dried on sterilized filter paper. The seed in each pot was covered with soil treated in the same manner as that in the pot. The pots were set on a freshly painted wood surface which was washed with mercuric chlorid. Each pot was set in a saucer which had been sterilized, and each two pots were covered by an open top bell-jar which had been wiped out with mercuric chlorid and the opening plugged with sterilized cotton. The jars were sealed to the shelf with a wax mixture to keep out insects. To provide a method of watering, a glass tube was introduced through the upper opening of the bell-jar into the saucer of the pot containing the seedlings. Water could be siphoned over into the saucer from the bottle in which it had been sterilized without serious danger of contamination.

The inoculations were made on April 15 by shaking up a small piece from a plate culture of the fungus in sterile water, the water containing the spores being poured over the soil of the pot to be inoculated. The following day, damping off appeared in three of the pots, and two days later on nearly all those inoculated. The bell-jars appeared to furnish conditions favorable to the rapid action of the fungus.

On April 23, diseased seedlings or growths of fungi from the different inoculated pots were examined, and the spores (macroconidia) of the damping off fungus were found in great abundance. The seedlings in the uninoculated pots remained healthy. The pots were not watered after April 30, and little attention was paid to them, as the two weeks was thought to be a sufficiently long time for the fungus to produce results. On May 31 the pots were examined and the seedlings were found to be dead in all the inoculated pots but those receiving the acid which were still healthy as were all but two of the uninoculated pots. The numerical results of this experiment are given in the following table:

Pot number.	Number germinated.	Number attacked within 5 days.	Average percent loss at the end of 5 days.	Average percent loss at the end of 15 days.	Pot number.	Number germinated.	Number attacked within 5 days.	Average percent loss at the end of 5 days.	Average percent loss at the end of 15 days.
1	30	24	26.6	80.0	13	19	19	68.4	100.0
2	26	22	42.3	84.6	14	18	17	72.2	94.4
5	10	8	30.0	80.0	17	14	8	28.5	57.1
8	21	17	47.2	80.9	18	33	21	21.2	63.6
9	13	13	46.1	100.0	19	32	26	6.2	81.2
10	34	33	38.2	97.0	20	25	17	4.0	68.0

SUMMARY OF ABOVE TABLE

Treatment of soil.	Average percent loss at the end of 5 days.	Average percent loss at the end of 15 days.
Reaction unchanged	32.9	81.5
Plus 4 grs. hardwood ashes	43.8	92.6
Plus 8 grs. hardwood ashes	70.3	97.2
Plus ½ cc. sulphuric acid	14.9	67.4

On account of the very favorable conditions created by the use of the bell-jars, the disease was very active, so that the figures at the end of 15 days do not show the differences that are shown in the experiments. But the results do indicate that an alkaline reaction of the soil favors the development of the disease and that, within limits, increasing the alkalinity increases the virulence of the attack. The relation of this fact to nursery practice would suggest the importance of the use of acid fertilizers and the danger in using those containing large amounts of alkali. It has not been determined whether this effect of an acid reaction is due to an increase in the vigor of the host or to a less favorable condition for the parasite, although the writer is inclined to accept the latter view.

EFFECT OF FERTILIZATION ON THE VIRULENCE OF THE DISEASE

In the light of the results previously secured, it was thought advisable during the summer of 1910 to test the effect of various chemical and animal fertilizers upon the virulence of the disease under actual nursery conditions. It was hoped in this way to find a fertilizer which would be safe to use, or at least to find those which it would be best not to use.

On July 6 two beds were prepared for sowing. A pailful of infected soil was sprinkled over them, and very thoroughly raked in. Both beds were then divided lengthwise by board partitions, and to half of each bed was applied air-slaked lime at the rate of 2,000 pounds per acre. The lime was applied to the north half of bed 1 and to the south half of bed 2, and was carefully raked in. On July 9 the soil from various places on each side was tested with litmus and found to be alkaline where the lime had been applied, and neutral in the other half of the bed. Each bed was divided crosswise into six equal parts which were numbered consecutively from 1 to 12 (figure 10).

1	2	3	4	5	6
7	8	9	10	11	12

Fig. 10. Plan of bed used in testing effect of various fertilizers on damping off.

On July 18 fertilizers were applied to the different parts, according to the scheme given below. The small amount of the chemical used being previously in each case mixed with a quantity of the soil, so as to make possible an even distribution.

Part.	Fertilizer.	Rate per acre.
1	Control	
2	Sodium nitrate	200 pounds
3	Tankage	400 pounds
4	Potassium carbonate	400 pounds
5	Potassium chlorid	400 pounds
6	Acid phosphate	1000 pounds
7	Control	
8	Base goods	1000 pounds
9	Complete fertilizer (2, 5, 6 above)	1600 pounds
10	Hardwood ashes	2000 pounds
11	Lime kiln ashes	2000 pounds
12	Compost	1qt. per sq. ft.

The two beds were sown with Scotch pine on July 29. Germination was moderately good, and damping off was present throughout the two beds. The seedlings were counted August 16 after germination was completed, and again on September 12, when damping off had practically ceased. The figures are given in the following table:

Part.	Total germination.		Total stand Sept. 12.		Number attacked.		Percent attacked.	
	Limed	Unlimed	Limed	Unlimed	Limed	Unlimed	Limed	Unlimed.
1	670	914	369	630	301	284	44.9	31.0
2	682	981	392	613	290	368	42.5	37.5
3	1239	1240	1109	1177	130	63	10.4	5.0
4	533	1065	311	767	222	298	41.6	27.7
5	688	1076	333	736	355	340	51.6	31.6
6	821	939	516	665	305	274	37.1	29.2
7	687	750	411	517	276	233	40.1	31.0
8	806	726	445	474	361	352	44.7	34.6
9	751	932	484	558	267	374	35.5	40.1
10	469	599	266	379	203	220	43.3	36.8
11	547	513	340	321	207	192	37.8	37.7
12	729	745	527	629	202	116	27.8	15.5

As will be readily seen, the above figures show with one exception a consistent increase in the amount of damping off where the soil was limed. This accords very well with the earlier findings. There appears to be no striking difference between the different fertilizers except in the case of part 3 which received tankage. This part gave excellent germination, and a very small amount of damping off. This material should receive further study as it may prove to be of real value in lessening the disease. The next best part appears to be the one receiving the compost. This material is now regularly used in the nursery seed beds and usually gives excellent results. It is made by composting together well-rotted horse manure and muck, half and half. Besides the plant food contained, it probably carries considerable amounts of organic acids, and its use would seem to approximate more closely the conditions under which the seedlings naturally grow, than the use of chemical fertilizers.

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EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN No. 161

JANUARY, 1912

FOREST SERVICE PUBLICATION No. 9.

Hemlock in Vermont

Comparative Study of Log Rules

BURLINGTON:
Free Press Printing Co.,
1912.

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FOREST SERVICE PUBLICATION NUMBER 9
BULLETIN 161: HEMLOCK IN VERMONT
COMPARATIVE STUDY OF LOG RULES

By A. F. Hawes, State Forester

PART I. HEMLOCK IN VERMONT

Introduction

According to a report of the United States Forest Service for 1909 the average annual lumber cut in Vermont is 351,000,000 board feet, 123,000,000 of which are spruce and 62,000,000, hemlock. These two species together, therefore, constitute over half the present lumber output.

A detailed discussion was made by the writer a year ago of the management of white pine forests[1], a type which is at present not extensive in Vermont, but which will be of increasing value as time goes on and which should always be encouraged. A matter of more immediate importance in Vermont is the management of spruce forests, such as must always cover the greater part of her mountain areas. The United States Forest Service has long been securing data on spruce and the results of its studies, shortly to be published, will furnish the basis for a bulletin on the management of spruce. Pending the issuance of these data it seems worth while at this time to devote a publication to hemlock, because of its present importance in Vermont's lumber business and of the questions concerning management which arise.

RANGE

Hemlock occurs throughout Vermont from the northern boundary to the Massachusetts line, being formed in the valleys and on the mountain slopes, although it does not ascend the mountains as high as does the spruce. Neither is it characteristic of the plains as is the pine. It prefers the lower slopes of the mountains and the sides of cool ravines. Hemlock does not occur here in pure forests and, consequently, is nowhere of prime importance. It is usually found mixed with such trees as spruce and basswood on the steeper rocky slopes, with birch, maple and beech on the richer soils, and with pine in the Connecticut and Champlain valleys. It is now being lumbered in many forests where the original pine or spruce has been cut off and the hemlock left on account of its inferiority. Most of it is of old original growth, as indicated by the table of ages (page 8).

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[1] Vt. Sta. Bul. 156 (Forest Service Publication No. 4) (1911).

VOLUME TABLE

The most accurate method of timber estimation is by the use of the so-called volume tables, tables based on the measurement of a great many felled trees.[1] Thus far reliable American volume tables have been constructed for only a few species. The data upon which the following hemlock volume table was constructed, was secured in 1910 by the careful measurement of 320 felled trees in the towns of Granville, Rochester and Danville, thus representing two quite widely separated regions. The trees measured were felled for regular logging operations and were sawed into twelve foot logs. The measurements taken as the basis of the table were: diameters both inside and outside the bark at the top of each log. From these figures obtained in the field each log was scaled in the office by the Vermont rule and the total contents of each tree obtained in board feet. The trees were then classified according to diameter and height and each group was averaged. The averages were then evened off by a curve and final results obtained which appear in the following table. The italicised figures represent the average volume of each diameter class regardless of height; and for ordinary application, where the heights of standing trees are not known, these figures may be assumed to be correct.

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[1] See such tables for white pine in Vt. Sta. Bul. 156, pp. 117-118 (Forest Service Publication No. 4.) (1911).

TABLE I. VOLUME TABLE FOR HEMLOCK IN BOARD FEET: VERMONT RULE

Diameter at breast height	Total height of tree						
	40 feet	50 feet	60 feet	70 feet	80 feet	90 feet	100 feet
	Board feet						
8 inches,	*35*						
9 inches,	*42*	51	60				
10 inches,	53	*66*	76				
11 inches,	66	81	*94*	109	120		
12 inches,	74	93	*113*	132	153		
13 inches,		118	132	*156*	180		
14 inches,		140	160	*182*	214	241	
15 inches,		160	185	*217*	248	284	
16 inches,			214	*248*	282	320	
17 inches,			250	283	*317*	360	
18 inches,			293	330	*364*	405	454
19 inches,			335	372	*408*	450	500
20 inches,			380	415	*454*	498	545
21 inches,				455	*497*	545	590
22 inches,				491	*540*	594	650
23 inches,				520	582	*650*	710
24 inches,					626	*712*	780
25 inches,					675	777	836
26 inches,					742	*840*	906
27 inches,					790	*897*	968
28 inches,						*978*	1040
29 inches,						*1040*	1100
30 inches,						*1100*	1160

If this volume table is compared with that given for white pine[1] it will be found that the two do not greatly differ.

TABLE II. COMPARATIVE VOLUMES OF PINE AND HEMLOCK OF CERTAIN SIZES

	White pine, board feet	Hemlock, board feet
Trees 10 inches in diameter, 50 feet high........	75	66
Trees 15 inches in diameter, 60 feet high........	195	185
Trees 15 inches in diameter, 90 feet high........	340	284
Trees 20 inches in diameter, 80 feet high........	485	454
Trees 25 inches in diameter, 80 feet high........	715	675
Trees 27 inches in diameter, 90 feet high........	905	897

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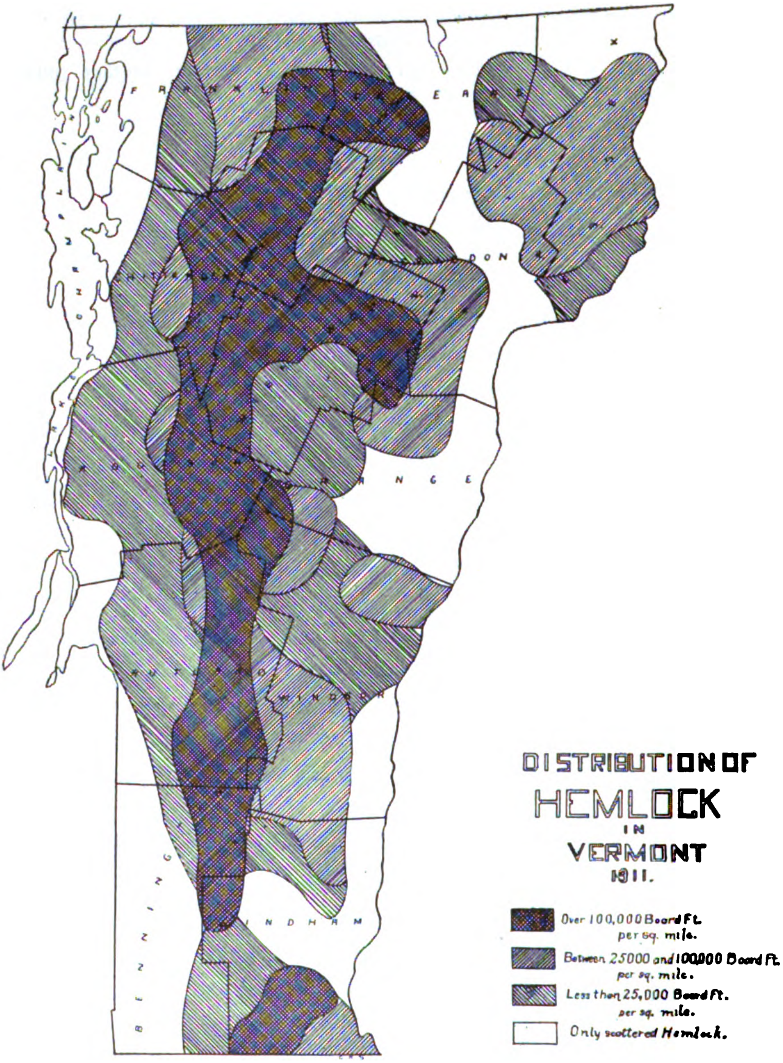
[1] Vt. Sta. Bul. 156, p. 117 (1911).

DISTRIBUTION OF
HEMLOCK
IN
VERMONT
1911.
Over 100,000 Board Ft. per sq. mile.
Between 25000 and 100,000 Board Ft. per sq. mile.
Less than 25,000 Board Ft. per sq. mile.
Only scattered Hemlock.
WINDSOR
INDHAM
RANGE
DON

It will be noticed that the figures for pine are invariably higher than those for hemlock. While this may be partially due to the characteristic forms of the two species, it is also undoubtedly due to the fact that the volume table for pine is based on mill tallies, while the hemlock table is based on the Vermont rule, which considerably underruns the mill tallies, especially for large logs, as is shown on page 32.

Hemlock has always been an important source of tanning material on account of the tannic acid in its bark. While there are now many substitutes, large quantities are still used; and the bark of a hemlock forest may furnish a considerable revenue. Hence in order to estimate the total value of a hemlock stand, it is necessary to be able to determine the amount of bark as well as that of lumber. The following volume table for bark was constructed by subtracting the volumes of the trees inside the bark from their volumes outside the bark, and multiplying by .4[1] on the assumption that 40 percent of a stacked cord of bark, as it is ordinarily stacked, is solid bark.

TABLE III. VOLUME TABLE FOR HEMLOCK BARK IN STACKED CORDS

Diameter at breast height	Volume of bark in cords	Diameter at breast height	Volume of bark in cords
8 inches,	.03	19 inches,	.20
9 inches,	.05	20 inches,	.22
10 inches,	.06	21 inches,	.25
11 inches,	.07	22 inches,	.28
12 inches,	.08	23 inches,	.31
13 inches,	.09	24 inches,	.34
14 inches,	.10	25 inches,	.37
15 inches,	.12	26 inches,	.40
16 inches,	.14	27 inches,	.43
17 inches,	.16	28 inches,	.46
18 inches,	.18	29 inches,	.50

A comparison of this statement with table I shows that the ratio between lumber and bark varies. For example 1,000 board feet of 10 inch trees would peel according to table III, 0.90 of a cord of bark, while 1,000 board feet of 20 inch trees would peel 0.48 of a cord of bark. It is a common practice of lumbermen to consider that 1,000 board feet of hemlock will yield a half cord of bark.

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[1] Schenck, "Forest Mensuration," p. 14 (1905). The accuracy of this factor was borne out by our investigations of a few piles of bark.

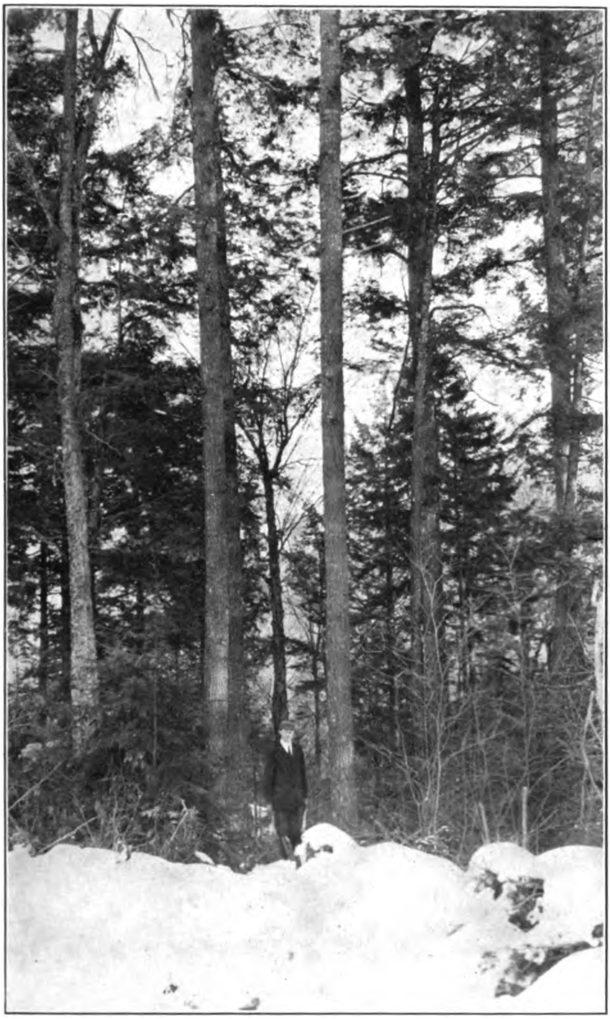
AGE OF HEMLOCK

Most Vermont hemlock is old growth that has escaped cutting either because of the inferiority of the lumber or its inaccessibility. The figures upon which this study were based were all obtained from such old growth trees; hence the average ages as given for different diameters do not indicate the possible growth at any definite age, but the actual ages of the trees as they run in the woods throughout the state. Hemlock is very tolerant of shade and will persist under a dense cover, making almost no growth where other species would die. On this account small size is no indication of youth, many suppressed trees not over a foot in diameter being two hundred years old.

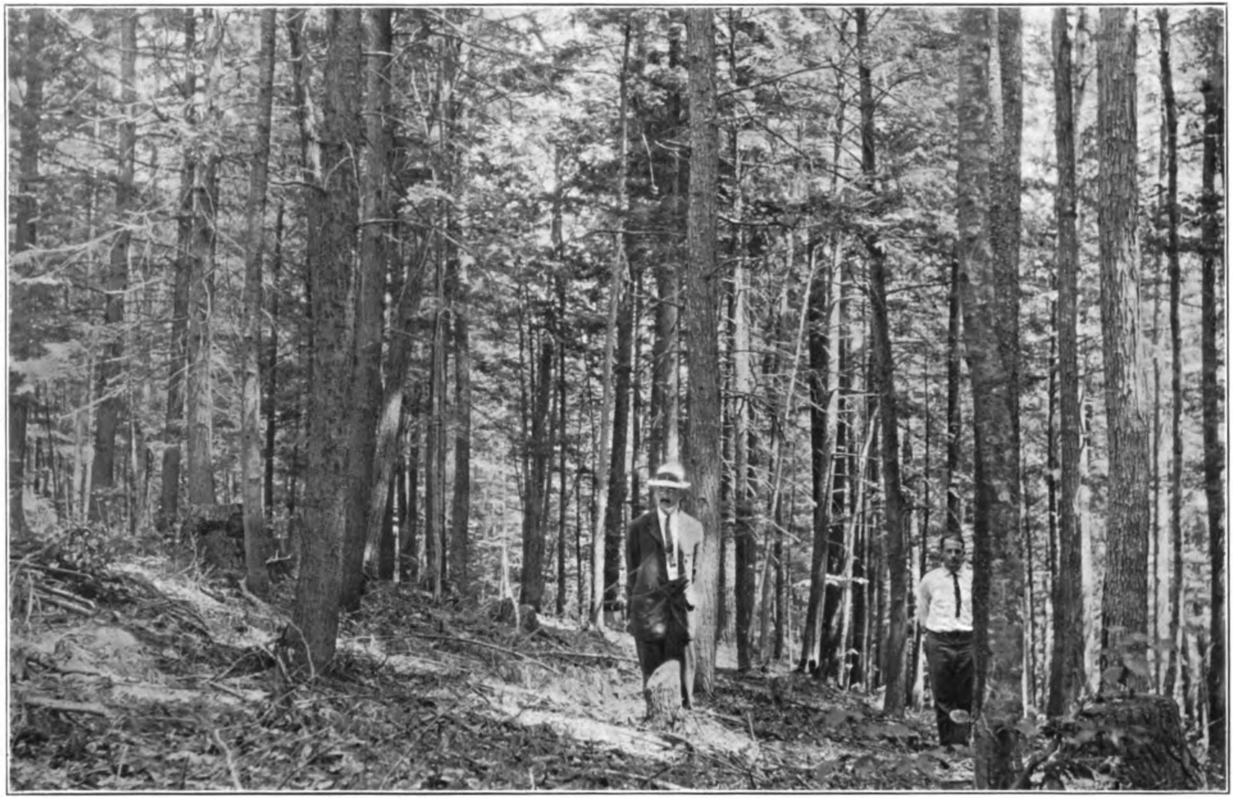
TABLE IV. AVERAGE AGE OF HEMLOCK

Diameter at breast height	Age	Diameter at breast height	Age
8 inches,	140 years	19 inches,	230 years
9 inches,	150 years	20 inches,	238 years
10 inches,	159 years	21 inches,	246 years
11 inches,	167 years	22 inches,	254 years
12 inches,	175 years	23 inches,	262 years
13 inches,	183 years	24 inches,	270 years
14 inches,	190 years	25 inches,	278 years
15 inches,	198 years	26 inches,	286 years
16 inches,	206 years	27 inches,	294 years
17 inches,	214 years	28 inches,	301 years
18 inches,	222 years	29 inches,	310 years

While the above figures indicate the astonishingly slow increase of old growth hemlock, as a matter of fact other tolerant species occurring under similar conditions are equally aged. Old growth spruce, for example, as studied in New Hampshire was found to average 94 years at 4 inches breast height, 225 years at 20 inches, etc.; while second growth spruce under more favorable conditions of light and moisture showed a fairly rapid rate of increase.



Thrifty hemlock left for the protection of a watershed, although mature.



Forest belonging to the Vermont Sanatorium, Pittsford, from which the poorer beech and large hemlock have been removed to help the growth of the remaining stand. This cutting resulted in a good profit.

The following tables of values is based on the two preceding volume tables and on the age table and shows how slowly old growth hemlock increases in value.

TABLE V. VALUE OF HEMLOCK FOR DIFFERENT DIAMETERS

Diameter	Average age	Volume	Volume of the bark	Value of lumber at $5 per M[1] stumpage	Value of bark at $1.50 per cord[1]	Total value of tree standing
8 inches,	140 years	35 bd. ft.	.03 cords	$0.17	$0.05	$0.22
9	150	42	.05	0.21	0.07	0.28
10	159	66	.06	0.33	0.09	0.42
11	167	94	.07	0.47	0.10	0.57
12	175	113	.08	0.57	0.12	0.69
13	183	156	.09	0.78	0.13	0.91
14	190	182	.10	0.91	0.15	1.06
15	198	217	.12	1.08	0.18	1.26
16	206	248	.14	1.24	0.21	1.45
17	214	317	.16	1.58	0.24	1.82
18	222	364	.18	1.82	0.27	2.09
19	230	408	.20	2.04	0.30	2.34
20	238	454	.22	2.27	0.33	2.60
21	246	497	.25	2.49	0.37	2.86
22	254	540	.28	2.70	0.42	3.12
23	262	630	.31	3.15	0.46	3.61
24	270	712	.34	3.56	0.51	4.07
25	278	777	.37	3.88	0.55	4.43
26	286	840	.40	4.20	0.60	4.80
27	294	897	.43	4.48	0.64	5.12
28	301	978	.46	4.89	0.69	5.58
29	310	1040	.50	5.20	0.75	5.95
30		1100		5.50		6.35

From these figures it will be seen that a tree ten inches in diameter is worth twice as much as is an eight inch tree, but that it takes 19 years for the value to double; that a tree eighteen inches in diameter is worth twice as much as one fourteen inches in diameter but that it requires 32 years to achieve this gain; that a twenty-seven inch tree is worth twice as much as a twenty inch tree and that this doubling in value requires 56 years. Since a doubling of value in 16 years represents only 4½ percent compound interest, it will be seen that the growth of hemlock throughout its age to maturity represents a very poor investment.

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[1] Of course the values of standing trees vary according to their situation. It should not be understood that hemlock lumber is always worth $5 per thousand stumpage, or bark $1.50 per cord, but simply that at these prices standing trees of various sizes would be worth the prices given in the final column.

FORM FACTOR OF HEMLOCK

So-called "form factors" for all important species have been constructed in Europe. These are extensively used there in timber estimating. Where volume tables exist they are unnecessary, but at the same time they furnish a very interesting standard by which to compare the forms of various species.

A form factor is the ratio of the volume of a tree to that of a cylinder of the same base and height. In the construction of the form factor given below the volume of the cylinder was obtained by multiplying the area of the cross section at breast height by the total height of the tree. It will be readily seen that a form factor is always a fraction, and that the more tapering a tree the smaller is this fraction. For convenience it is expressed as a decimal. Inasmuch as trees make their main height growth first and then thicken out, it will be understood that the form factor usually increases with the age of a tree after the main height growth has been finished. Form factors made for the hemlocks of different diameters and heights employed in this study, did not vary appreciably. This relative uniformity was probably due to the fact that the trees were all practically mature and that their trunks were equally filled out. This form factor for hemlock based on 314 trees is .547. The form factors for balsam fir, based on 94 trees, is stated as .457[1]. Evidently hemlock is much fuller boled than is fir. Graves[2] gives tables of form factors for several European species. As a matter of interest for comparison with Vermont hemlock the form factor of Norway spruce over 90 years old is shown as follows:

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[1] Forest Quarterly I., p. 57 (1903).

[2] "Forest Mensuration," p. 407 (1908).

TABLE VI. FORM FACTOR OF NORWAY SPRUCE OVER 90 YEARS OLD

Diameter breast high in inches	Form factor	Diameter breast high in inches	Form factor
4	.559	20	.427
8	.505	32	.367
12	.475	40	.354
16	.449		

Since the hemlock form factor is based largely on trees between 12 and 20 inches in diameter, a comparison with the spruce figures for these diameters shows that the hemlock tapers less than does the Norway spruce, that, in other words, a hemlock of the same diameter and height would saw out more than would a fir or Norway spruce. Unfortunately no form factor is extant at present for native spruce.

TAPER TABLES

While form factor tables are interesting as showing the comparative forms of different species, they are not as valuable as a means of timber estimating in this country, where the board foot is the standard of measurement, and where innumerable log rules obtain, as they are in Europe where cubic measure is the rule.

For our purpose, as a means for the construction of a volume table by any of the various log rules, a taper table is the most universally useful method of expressing the average form of trees of different dimensions. A taper table is made by classifying together all trees of the same diameter at breast height, and of the same height, as, for example, all trees fifteen inches in diameter and between fifty-five and sixty-five feet in height. The diameters of these various trees at the top of each twelve foot log are averaged and the results for the various classes evened by a curve. The final table therefore, gives the top diameter of each twelve foot log of the average tree of each diameter and height class.

The chief use of taper tables is in the construction of volume tables. The method to be pursued is simply to scale up with the desired log rule all the logs of each tree, and add them up for the total volume in board feet. The following example illustrates the method and shows the comparative results by the Doyle and Champlain rules.

TABLE VII. VOLUME IN BOARD FEET OF A TREE 12 INCHES IN DIAMETER AND 60 FEET HIGH BY THE DOYLE AND THE CHAMPLAIN RULES, CONSTRUCTED FROM TABLE VIII

	Diameter at top of each 12 foot log in inches				Total volume
	9.9	8.7	6.8	3.8	
Doyle rule, board feet.....	27	19	5	..	51 board feet
Champlain rule, board feet	53	42	24	6	125 board feet

TABLE VIII. TAPER TABLE OF HEMLOCK

Top diameters of 12 foot logs, in inches.

Diameter at breast height	Trees 50 feet high				Trees 60 feet high				Trees 70 feet high				
	Number of logs from stump (1st) to top												
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	5th
11	8.7	7.2	5.0	1.4	9.1	8.0	6.3	3.5					
12	9.8	8.5	6.1	2.4	9.9	8.7	6.8	3.8	10.0	9.1	7.8	5.6	2.5
13	10.8	9.0	6.5	2.0	11.0	9.3	7.2	4.1	11.1	10.0	8.3	6.0	2.9
14					11.5	10.0	8.0	4.6	11.6	10.4	8.9	6.6	3.2
15					12.3	11.0	9.0	5.4	12.5	11.4	9.6	6.9	3.3
16					13.1	11.7	9.5	6.0	13.2	12.0	10.4	7.9	4.1
17					14.0	12.5	10.4	6.8	14.1	13.1	11.8	9.4	5.6
18					14.7	13.3	11.2	7.6	14.8	13.5	11.8	9.0	4.9
19									15.5	14.5	13.0	10.5	5.9
20													
21													

TABLE VIII (*Continued*)

Top diameters of 12 foot logs, in inches

Diameter at breast height	Trees 80 feet high						Trees 90 feet high						
	Number of logs from stump (1st) to top												
	1st	2nd	3rd	4th	5th	6th	1st	2nd	3rd	4th	5th	6th	7th
13	11.2	10.3	9.1	7.4	5.0	2.1							
14	11.7	10.8	9.7	8.0	5.4	2.2							
15	12.8	11.7	10.3	8.4	5.6	2.3							
16	13.2	12.2	10.9	9.0	6.3	2.8	13.3	12.4	11.4	10.0	7.9	4.9	1.5
17	14.1	12.8	11.6	9.7	6.6	2.6	14.2	13.1	12.1	10.5	8.2	5.0	1.0
18	14.9	13.7	12.3	10.2	7.3	3.3	15.0	13.9	12.7	11.0	8.5	5.7	2.2
19	15.6	14.6	13.2	11.1	7.8	3.3	15.7	14.6	13.3	11.6	8.9	5.5	1.8
20	16.2	15.1	13.5	11.2	7.7	3.1	16.5	15.7	14.4	12.6	9.8	6.0	1.4
21	17.0	16.0	14.4	12.1	8.4	3.5	17.4	16.6	15.3	13.3	10.4	6.8	2.4
22	17.9	16.8	15.3	13.0	9.2	4.0	18.1	17.3	16.2	14.4	11.4	7.1	2.1
23	18.8	17.5	15.8	13.5	9.7	4.4	19.8	18.2	16.9	15.0	12.0	7.8	2.5
24	19.6	18.2	16.5	13.0	10.0	4.4	20.3	19.0	17.4	15.4	12.5	8.0	2.4
25	20.4	18.9	17.2	14.4	10.2	4.6	21.4	19.8	18.2	16.2	13.0	8.4	2.5
26	21.3	19.7	18.0	15.2	10.9	4.7	21.8	20.6	17.1	16.9	13.7	8.9	3.0
27	21.8	20.4	18.7	15.9	11.4	5.2	22.3	21.1	19.5	17.3	13.9	8.9	3.0
28	22.9	21.5	19.5	16.6	12.3	5.4	23.9	22.5	20.5	17.9	14.0	9.0	3.0
29							24.9	23.0	20.8	18.1	14.3	9.2	3.1
30							25.5	23.6	21.4	18.6	14.7	9.5	3.1
31							26.4	24.4	22.0	19.0	15.0	10.0	3.5

APPLICATION OF VOLUME TABLE

The following table based on the measurements of an acre in Danville is given as an illustration of a typical acre in which hemlock forms an important part of the stand, and also to show the use of a volume table.

TABLE VIII. STAND OF ONE ACRE HEMLOCK AND HARDWOODS, DANVILLE, VT.

Diameter at breast height	Number of trees per acre				Volume of hemlock, board feet	
	Hemlock	Maple	Birch	Beech	Per tree from table I	Total
5 inches,	2	4	3			
6 inches,	1	3	2			
7 inches,		4	1			
8 inches,	4	2	1		35	140
9 inches,	3	7		1	42	126
10 inches,	1	6		1	66	66
11 inches,	1	5	2		94	94
12 inches,	1	1	2		113	113
13 inches,	1	5			156	156
14 inches,	4	2	5		182	728
15 inches,	2	3	2		217	434
16 inches,	3	2		1	248	744
17 inches,	2		1		317	634
18 inches,	4	1	1		364	1456
19 inches,	1		2		408	408
20 inches,		1	1		454	
22 inches,	2				540	1080
23 inches,	2		1		650	1300
24 inches,	2				712	1424
26 inches,	2				840	1680
29 inches,	2				1040	2080
	40	46	24	3		12,173

By the use of the volume table the total stand of hemlock on this acre is estimated at 12,000 board feet. This may be considered as a very good stand, for although many better may be found, most forests have much less hemlock per acre.

REPRODUCTION

Wherever hemlock seed trees are plentiful, reproduction is usually fair. It does not, however, take possession of old pastures as do the pine and spruce, and it is practically never found on the burns on the mountains where poplar, birch, and spruce are so common. Hemlock, however, seems to possess the ability to reproduce on a hardwood litter of leaves better than do either pine or spruce, and frequently young hemlocks are seen starting under old hardwoods. An example of such reproduction is given below. But while there is considerable small reproduction of hemlock there is almost no second growth in the stage so commonly found of spruce and pine. Hence figures of the increment of second growth hemlock are entirely lacking. Indeed it is doubtful whether there will ever be another growth of any account to take the place of the old trees.

TABLE IX, SHOWING REPRODUCTION OF HEMLOCK UNDER MAPLE, 1/16 ACRE, IN DANVILLE, VERMONT

Maple

Diameter breast high in inches,	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Number of trees,	7	3	3	3	8	5	5	1	Total, 35

Hemlock

Height—feet,	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Number of seedlings,	1	1	3	11	14	21	15	14	4	2	1	Total, 87

The following reproduction studies by forestry students of the University of Vermont, while made with no special reference to hemlock, show very well the relation existing between hemlock in the main stand and the reproduction.

Series A, numbers 1 to 6 inclusive, was made on Sam's mountain, west of Brattleboro, on the east and west slopes of this ridge which has a north and south direction.

1. An open stand with light shade; soil well drained and gravelly.

Species	Percentage of trees in main stand	Percentage of seedlings in reproduction
Beech	85%	90%
Hemlock	4%	8%
Maple	4%	Pine 2%
Black cherry	1%	
Birch	5%	
Hornbeam	1%	
	100%	100%

2. Soil rocky; shade dense.

Species	Percentage of trees in main stand	Percentage of seedlings in reproduction
Hemlock	85%	95%
Maple	13%	White pine 5%
Beech and birch	2%	
	100%	100%

3. Exposure east and south; soil rocky, light and well drained.

Species	Percentage of trees in main stand	Percentage of seedlings in reproduction
Hemlock	69%	2%
Maple	15%	
Beech	5%	98%
Pine	3%	
Birch	7%	
Ash	1%	
	100%	100%

4. Exposure east and south; shade dense.

Species	Percentage of trees in main stand	Percentage of seedlings in reproduction
Hemlock	45%	100%
White pine	45%	
Maple	4%	
Birch	6%	
	100%	100%

5. Steep exposure east and south.

Species	Percentage of trees in main stand	Percentage of seedlings in reproduction
Black oak	70%	Sprouts 5%
Hornbeam	10%	75%
Maple	15%	
Hemlock	5%	20%
	100%	100%

6. Exposure west; shade medium, soil shallow.

Species	Percentage of trees in main stand	Percentage of seedlings in reproduction
Hemlock	65%	30%
Birch	20%	30%
White pine	3%	
Maple	4%	10%
Ash	6%	30%
Cherry and oak	2%	
	100%	100%

Series B. was taken on a hillside in Barnet with a northern exposure.

7. Level land near stream at foot of slope; soil a wet, heavy black loam.

Species	Percentage of trees in main stand	Percentage of seedlings in reproduction
Fir	30%	17%
Hemlock	22%	15%
Maple	15%	10%
Cedar	11%	25%
Ash	10%	23%
Pine	6%	10%
Yellow birch	3%	
Black cherry	3%	
	100%	100%

8. Gentle north slope; soil a heavy loam.

Species	Percentage of trees in main stand	Percentage of seedlings in reproduction
Maple	35%	32%
Yellow birch	18%	15%
Fir	14%	10%
Hemlock	11%	10%
Beech	7%	3%
Basswood	6%	11%
Ash	5%	12%
Others	4%	7%
	100%	100%

9. Northwest slope, steeper and better drained than 7 and 8; soil a rich loam; stand much denser than 7 and 8 and reproduction was scarce.

Species	Percentage of trees in main stand	Percentage of seedlings in reproduction
Hemlock	38%	60%
Maple	16%	8%
Fir	16%	
Beech	10%	20%
Yellow birch	8%	5%
Basswood	5%	4%
Ironwood and cedar	7%	3%
	100%	100%

10. Situation similar to the preceding, but the stand, which was largely of hardwoods, had been considerably cut into so it was not nearly as dense.

Species	Percentage of trees in main stand	Percentage of seedlings in reproduction
Maple	30%	32%
Yellow birch	24%	7%
Hemlock	10%	6%
Fir	8%	9%
Beech	7%	
Ash	6%	20%
Others	15%	26%
	100%	100%

These ten canvasses throw much light on the matter of hemlock reproduction and the proportion which it forms of the whole reproduction of a stand under varying conditions. Thus in studies 2, 4 and 9 where the shade was dense, hemlock formed from 60 percent to 100 percent of all the reproduction; while in studies 1, 6 and 10 where there was plenty of light, it formed only 6 percent to 30 percent thereof. In other words, few other species are able to reproduce under dense shade as well as hemlock. Maple and beech rank next in their ability to reproduce under shade.

The occurrence of seedlings is not the only controlling feature in the formation of a second generation. Rapidity of height growth is quite as important. For this reason table x is of interest.

TABLE X.[1] SHOWING THE AGE OF HEMLOCK SEEDLINGS OF DIFFERENT HEIGHTS

Height, feet	Age, years	Height, feet	Age, years	Height, feet	Age, years
4	18	7	24	10	30
5	20	8	26	11	31
6	22	9	28	12	32

Measurements which have been taken of the growth of pine seedlings indicate that they reach the height of five feet in about half the time that hemlock requires, and that after that they grow relatively still faster. While figures dealing with spruce growth are lacking, numerous observations lead to the belief that its growth lies between those of pine and hemlock. This slow growth of hemlock is the controlling factor of its future in our forests. In the original forests where sheer persistence, so to speak, and ability to live under the densest shade, were chief requisites, the hemlock stood unchallenged. But with the inroads of lumbermen upon our forests new conditions have been brought about. The forest floor is no longer densely shaded. Other species, more rapid growing than is the hemlock, can now thrive, and to the energetic tree today belongs the forest, just as to the energetic man belongs success in business. This is why second growth stands of pine, spruce and hardwoods are found, but rarely of hemlock.

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[1] This table is based on 100 seedlings measured on the lot described by table ix.

SOUNDNESS

Seventy-eight percent of the three hundred old growth hemlocks studied were absolutely sound, while 22 percent were more or less decayed. Rot occurred almost entirely at the butt. In some cases a butt log 10 or 12 feet long had to be discarded, but usually the rot did not extend over 6 feet up the tree. Many of the trees included in this 22 percent were only beginning to show signs of rot at an age of 200 or 250 years, while many others were perfectly sound at 300 years. It was impossible to discover any relationship between size and the beginning of rot, for since all the trees studied were mature the smaller ones seemed to be quite as apt to be decayed as the larger ones. This, of course, would not be true of younger, growing trees. Similar observations on spruce in various parts of Vermont lead to the conclusion that this species is much more apt to be decayed than hemlock and that it cannot safely be left to such an advanced age as hemlock. The spruce is quite as apt to be affected above as below with red rot, which is due to a fungus, *Trametes pini*. It is not known whether the fungus causing the rot in hemlock is the same species or not, but it must be borne in mind that all tree rots, like other forms of decay, are due to some one organism or to organisms, and, therefore, are liable to spread from one diseased tree to another.

MARKET CONDITIONS

Hemlock lumber is coarse grained and is principally used for dimension material, the frames for buildings, planks for bridges, etc. Considerable quantities are also made into boards, part of which are planed and matched. It is used in the making of butter boxes in Vermont. Hemlock logs delivered at the mills bring from $9 to $12 per thousand board feet. Probably $10 is an average price. The sawed lumber f. o. b. the car at the mill brings from $16 to $18 per thousand board feet, a little less than is paid for the same grade of spruce. At $10 for logs at the mill it is clear that only under the most favorable circumstances and at points convenient to the mill, is it possible to realize $5 per thousand stumpage on hemlock. In the majority of cases $4 may be considered a fair stumpage price.

Hemlock bark was in great demand in the past. In some parts of the country trees were cut and peeled for their bark alone, and the logs left to rot in the woods. Substitutes for bark for tanning purposes, especially the extracts from South America, have largely taken its place, and relatively lumber is now of more importance. In some of the more inaccessible sections of Vermont hemlock bark is not utilized, but in most lumber operations the hemlock is cut in the early summer when it can be easily peeled, and the bark is shipped either to Boston or Morrisville. Bark is bought by the cord, but on the basis of a cord being equivalent to 2,240 pounds. The price paid usually varies from $6 to $7 per cord f. o. b. the car, or from $7 to $8 delivered, the average price f. o. b. being probably $6.50. Large quantities of bark are shipped annually to Morrisville from Newport, Lyndon, Montpelier, Barre, Middlesex, Waterbury, Stowe, Bethel, Bradford and points as far south as White River Junction and as far north as Sherbrooke, P. Q.

It costs from $2 to $3 a cord to cut hemlock trees and peel and pile the bark. Probably $2.50 is an average cost. On a good down hill road two cords of bark can be hauled to a load, so that the cost of hauling varies from about $2 for a five mile haul to $2.50 for an eight mile haul. It costs about 25 cents a cord to car the bark. Evidently the cost of the bark f. o. b. the car may easily range from $4.50 to $6 per cord, leaving a stumpage value to the owner, acting as his own operator, varying from nothing to $2.50 per cord. Probably $1.50 per cord is an average value. Obviously $1 a cord for bark on the stump would be an outside price to pay unless it was exceptionally well located as regards haul and freight charges.

MANAGEMENT

The foregoing statements make it clear that hemlock is extremely slow growing, that it is of less value than are some of the more rapidly growing species, notably pine and spruce, and that it is not forming second growth forests as are several species. Such being the case but one form of advice can be given to owners of standing hemlock, namely, to cut out the hemlock and see that the land is covered with some more profitable species. In many cases natural reproduction of pine, spruce or fir can be obtained by leaving a sufficient number of seed trees. It should be explained, however, that fir is a more valuable tree to raise than is the hemlock because it is so much more rapid growing; not because of any superiority of its lumber. If it requires seventy-five years to produce a certain amount of hemlock lumber and the same amount of fir can be raised in forty years, the natural advantage of fir will be readily recognized. Figures are so far lacking to prove just what is this relationship between hemlock and pine, spruce and fir, but they will certainly be to the disadvantage of hemlock. To secure natural reproduction of spruce and fir one should understand that not only are several seed trees per acre of those species necessary, but that the ground cover must be favorable for a germinating bed. These species, especially the spruce, do not start well on hardwood leaf litter, because their roots must reach mineral soil at an early age and they are unable to penetrate a thick layer of leaves. For this reason most of the hardwood trees should be cut, except such as are needed to protect the spruce seed trees from windfall, a precaution which is quite necessary in view of the fact that the spruce has a shallow root system and is especially apt to be thrown over when left exposed. It might at first seem that it would be a good plan to burn the leaves. This, however, is not good policy when reproduction of spruce, fir or pine is sought, since burned areas are almost sure to be preempted at once by such light seeded species as poplar, paper birch and bird cherry to the exclusion of the slower growing softwoods. Where reproduction of these species is impossible on account of lack of seed trees, such a growth of poplar or paper birch may well prove more profitable than the present growth of hemlock. However, it is usually desirable to *plant* one of the more valuable species where desirable reproduction cannot be secured. On sandy land, pine should be planted; on the heavier soils and at higher elevations, Norway spruce may be recommended.[1]

It is not intended in this bulletin to be too radical with the hemlock. Most farmers wish to have in their woodlots enough softwood lumber to rebuild their set of buildings in case of fire. This is good economy, and where hemlock is the only softwood present in sufficient quantity it should be reserved. We would advise such farmers, however, to get an area started to pine or spruce as soon as possible, and to cut all unnecessary hemlock to a diameter of fifteen inches at most. They should realize that the money they can get from their hemlocks will yield them much bigger interest if invested in a young plantation, or in a savings bank, and would probably furnish more adequate fire protection if placed in a fire insurance policy.

Hemlock is a very beautiful tree because of its dark green foliage; hence groves of large hemlock trees are very desirable in estate forests. Some splendid examples occur near Burlington. This class of forests, owned by wealthy men for their beauty rather than for their commercial value, will be much more common in Vermont in the future than they are at present. Owners of forests suitable for such purposes should realize that trees often have a value to wealthy men far in excess of their lumber value, and should be governed accordingly. However, in most locations it will not pay to keep unproductive capital for the doubtful prospect of a land boom.

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[1] See Vt. Sta. Circs. 4 and 6—Forest Service publications 3 and 5—(1910, 1911).

Hemlock often occurs on very steep slopes, especially on the banks of streams, and on the lower ridges of mountains. On such situations trees should never be cut clean since soil wash is inevitable, and the runoff of water is made more irregular. Extensive cuttings of this nature cannot but effect spring freshets and summer droughts of springs and brooks. Public policy demands that such situations should always be kept covered with forest and the selection system[1] should, therefore, be practiced. That most land owners are unfortunately more or less selfish and desirous of handling their forests for profit instead of for the public good, should be recognized as only natural. This is the reason why such lands, especially the main range of the Green mountains so essential for its effect on runoff, should be owned by the State and preserved in a way not practicable for the private holder.

Except where forests are needed for their protective value or are valuable for aesthetic reasons, it may be laid down as an economic principle that it is nearly as bad to have a considerable portion of the State covered with overmature, unproductive forest as to have it lying idle covered with brush. As an example it may be assumed that there are at least 500,000 acres of waste land in Vermont, and possibly 500,000 acres of overmature timber. This leaves about 2,500,000 acres covered with growing forest of more or less value. Of course the overmature timber is by no means all hemlock, but all overmature timber is unproductive and the principle holds that the State is losing the income from a million acres, if the above figures are correct, whereas the income from this land, if covered with thrifty growing forest, could be from $2,000,000 to $5,000,000. It must not be supposed that there is no growth in an old stand. The point is that, through death and decay, as much or more timber is destroyed in an uncared for old forest in a year as grows in the same time.

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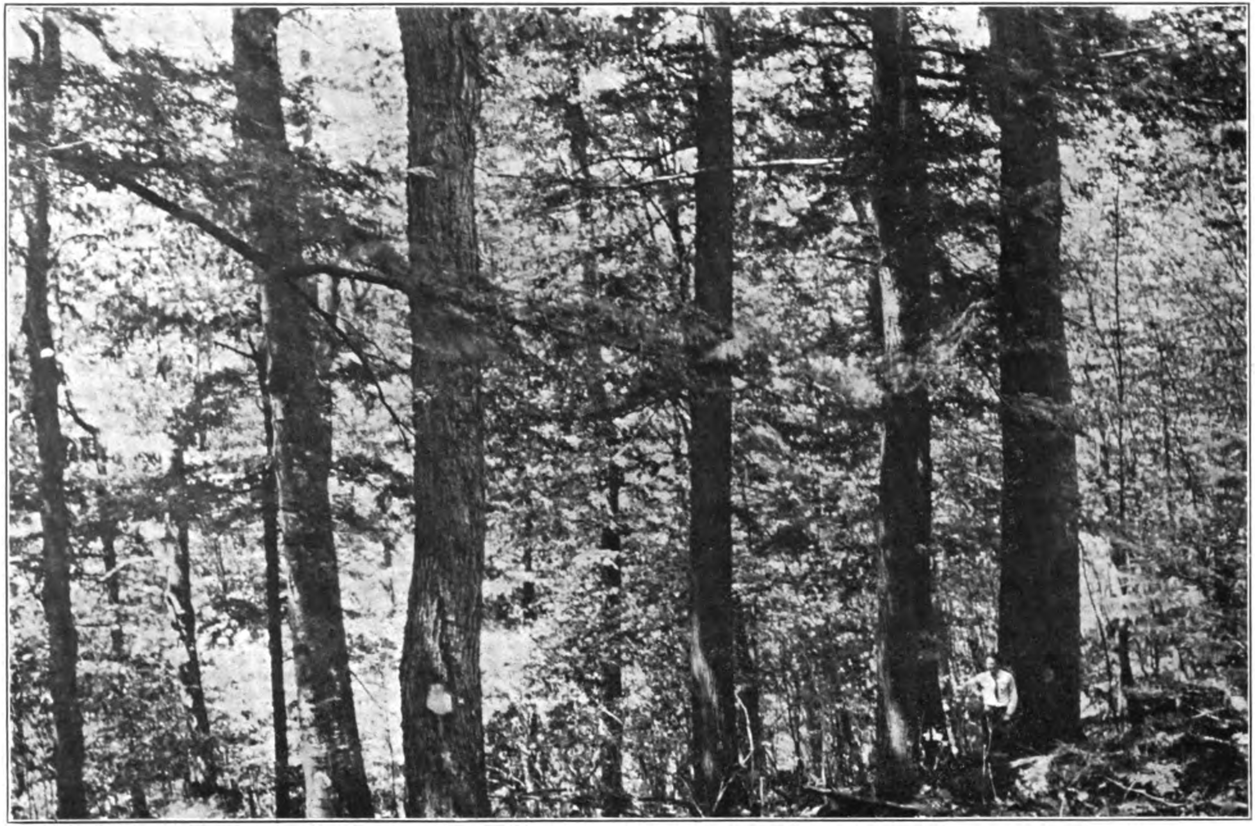
[1] See Vt. Sta. Bul. 156. (Forest Service Publication No. 4) (1911).

A cool ravine, which is the typical site of hemlock.



Overmature hemlock and hardwoods marked to be cut so as to make room for younger and faster growing trees.

PART II

COMPARATIVE STUDY OF LOG RULES[1]

In order to get accurate data on the correctness of some of the log rules in use in Vermont in comparison with actual mill tallies, 159 soft wood logs have been measured at the mill and the amount of lumber sawed from them noted. Tables xi, pages 26-31, and xii, page 31, give the results of this study.

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[1] A "log rule" or log scale is a table which purports to give the volume in board feet of logs of various diameters and lengths. Log rules are made in various ways, some from diagrams, others from actual mill tallies, and still others from mathematical formulae. The latter method of constructing log rules is the most accurate method. Of course the accuracy of the results attained in a given case depends upon the formula used.

The statutes of Vermont make the "Vermont rule" the legal scale. This rule is based on the premise that the board foot contents of a 12 foot log are equal to the product of the small diameter by half of itself.

Board feet $= D \times \frac{D}{2} \times \frac{L}{12}$ where D = diameter at the small end in inches and L = length of log in feet.

Thus for an 8 foot log, 16 inches at the top:

$$\text{Board feet} = 16 \times \frac{16}{2} \times \frac{8}{12} = 16 \times 8 \times \tfrac{2}{3} = 85.$$

One of the most common log rules in use throughout the country is the Doyle rule, sometimes wrongly called the Scribner rule. This is based on the formula: Board feet $= \left\{\frac{D - 4}{4}\right\}^2 \times L$

By this rule the tree described above would have the following contents:

$$\text{Board feet} = \left\{\frac{16-4}{4}\right\}^2 \times 8 = 9 \times 8 = 72.$$

Prof. A. L. Daniels of the University of Vermont has published the Champlain rule which is based on the formula:

$$\text{Board feet} = \frac{3.1416}{5} \times D^2 - D \frac{L}{12}$$

$$\text{Example: } \frac{3.1416}{5} \times 16^2 - 16 \times \frac{8}{12} = 97.$$

TABLE XI. MILL SCALE OF 12 FOOT SPRUCE LOGS SAWED INTO 1¼" LUMBER

Diameter, top end, inches	Number of log	Board feet	Total	Average scale per log, 1¼" boards	Scale by Vermont rule, 1" boards	Scale by Doyle rule, 1" boards	Scale by Champlain rule, 1" boards
8	1	41					
	2	37					
	3	36	114	38	32	12	32
9	4	42					
	5	45					
	6	48	135	45	40	19	42
10	7	48					
	8	42					
	9	57					
	10	60					
	11	56					
	12	65					
	13	49					
	14	60					
	15	53	490	54	50	27	53
11	16	78					
	17	78					
	18	78	234	78	60	37	65
12	19	88					
	20	84					
	21	88	260	87	72	48	78
13	22	95	95	95	84	61	93
14	23	121					
	24	118	239	119	98	75	109
15	25	138	138	138	112	91	126

TABLE XI. MILL SCALE OF 12-FOOT HEMLOCK LOGS SAWED INTO 1" BOARDS

Diameter, top end, inches	Number of log	Board feet	Total	Average scale per log, 1¼" boards	Scale by Vermont rule, 1" boards	Scale by Doyle rule, 1" boards	Scale by Champlain rule, 1" boards
7	26	28	28	28	24	7	24
8	27	41					
	28	33					
	29	40					
	30	30	144	36	32	12	32
9	31	44					
	32	39					
	33	40	123	41	40	19	42
11	34	76					
	35	70	146	73	60	37	65
12	36	95	95	95	72	48	78
14	37	120	120	120	98	75	109
15	38	127	127	127	112	91	126
16	39	143					
	40	123					
	41	140	406	135	128	108	145

MISCELLANEOUS SOFTWOODS, 12 FEET LONG, SAWED INTO INCH BOARDS

Diameter, top end, inches	Number of log	Board feet	Total	Average scale per log, 1" boards	Scale by Vermont rule, 1" boards	Scale by Doyle rule, 1" boards	Scale by Champlain rule, 1" boards
4	42	15	15	15	8		6
5	43	22					
	44	18	40	20	12	1	10
6	45	16					
	46	22					
	47	21					
	48	28					
	49	27					
	50	32	146	24	18	3	17
7	51	31					
	52	24					
	53	24					
	54	22					
	55	23					
	56	27					
	57	29					
	58	28	208	26	24	7	24
8	59	33					
	60	41					
	61	36					
	62	37	147	37	32	12	32
9	63	48					
	64	58	106	53	40	19	42
10	65	43					
	66	65	108	54	50	27	53
11	67	75	75	75	60	37	65
12	68	75					
	69	79	154	77	72	48	78
13	70	92	92	92	84	61	93
14	71	121	121	121	98	75	109
15	72	88					
	73	150	238	119	112	91	126
17	74	158	158	158	144	127	165

MISCELLANEOUS SOFTWOODS, 13 FEET LONG, SAWED INTO INCH BOARDS

Diameter, top end, inches	Number of log	Board feet	Total	Average scale per log, 1" boards	Scale by Vermont rule, 1" boards	Scale by Doyle rule, 1" boards	Scale by Champlain rule, 1" boards
4	75	14					
	76	18	32	16	9		6
5	77	15					
	78	19					
	79	17					
	80	17					
	81	20					
	82	25	113	19	13		11
6	83	22					
	84	16					
	85	21					
	86	19					
	87	26					
	88	30					
	89	30					
	90	30	194	24	19	3	18
7	91	26					
	92	25					
	93	37					
	94	30					
	95	32					
	96	30					
	97	34					
	98	31					
	99	36					
	100	38					
	101	49	368	33	27	7	26
8	102	38					
	103	38					
	104	36					
	105	40					
	106	39					
	107	41					
	108	39					
	109	40					
	110	40					
	111	42					
	112	42					
	113	46					
	114	48					
	115	55	584	42	35	13	35

Diameter, top end, inches	Number of log	Board feet	Total	Average scale per log, 1" boards	Scale by Vermont rule, 1" boards	Scale by Doyle rule, 1" boards	Scale by Champlain rule, 1" boards
9	116	35					
	117	38					
	118	39					
	119	43					
	120	49					
	121	50					
	122	54					
	123	52					
	124	62					
	125	54	476	48	44	20	45
10	126	29					
	127	38					
	128	45					
	129	53					
	130	53					
	131	55					
	132	51					
	133	58					
	134	60					
	135	65					
	136	75					
	137	90	672	56	54	29	57
11	138	74					
	139	64					
	140	68					
	141	67					
	142	79					
	143	86	438	73	66	40	70
12	144	75					
	145	87					
	146	85					
	147	90					
	148	88					
	149	100	525	87	78	52	85
13	150	120					
	151	113					
	152	113					
	153	115	461	115	92	66	101
14	154	105					
	155	137	242	121	106	81	118
15	156	156	156	156	122	98	137

Diameter, top end, inches	Number of log	Board feet	Total	Average scale per log, 1" boards	Scale by Vermont rule, 1" boards	Scale by Doyle rule, 1" boards	Scale by Champlain rule, 1" boards
16	157	176	176	176	139	117	157
17	158	174	174	174	157	137	178
20	159	216	216	216	175	208	251

TABLE XII. TOTAL CONTENTS OF ALL LOGS MEASURED—BY MILL SCALE, VERMONT, DOYLE AND CHAMPLAIN RULES

All logs 4 to 12 inches diameter (inclusive)

Diameter, top end, inches	Total number of logs	Total mill scale board feet	Total by Vermont rule	Total by Doyle rule	Total by Champlain rule
4	3	47	26	..	18
5	8	153	102	..	86
6	14	340	260	42	246
7	20	604	513	140	502
8	25	989	527	197	527
9	18	840	760	172	786
10	23	1270	1198	645	1267
11	12	893	756	452	810
12	12	1034	906	600	978
Total,	135	6170	5048	2248	5220

The mill tallies of the boards from these 159 logs as they came from the saw were almost all in excess of the scale as determined by any of the three log rules used. It is possible that some boards were tallied somewhat high as there is a tendency among some mill men to tally high when custom-sawing. As a rule, however, the tallies here given may be considered fair. It will be noticed that for many of the small logs the Vermont and Champlain rules corresponded closely with the mill tallies; while the Doyle, or Scribner rule as it is sometimes called, always gave very low results. It is evident that no one should

TABLE XII. TOTAL CONTENTS OF ALL LOGS MEASURED—BY MILL SCALE, VERMONT, DOYLE AND CHAMPLAIN RULES

All logs 13 to 20 inches (inclusive)

Diameter, top end, inches	Total number of logs	Total mill scale board feet	Total by Vermont rule	Total by Doyle rule	Total by Champlain rule
13	6	648	536	386	590
14	6	722	604	462	672
15	5	659	570	462	641
16	4	582	523	441	592
17	2	332	301	264	343
18					
19					
20	1	216	175	208	251
Total,	24	3159	2709	2223	3089
Total of all logs,	159	9329	7757	4471	8309

sell logs by this rule. Unfortunately a comparatively small number of large logs were measured.

Table xii shows that 135 logs between 4 and 12 inches in diameter sawed 6,170 board feet; that the total scale of these logs by the Vermont rule was 5,048 board feet or 82% of the mill scale; by the Doyle rule 2,248 board feet or 36 percent of the mill scale; and by the Champlain rule 5,220 board feet or 85 percent of the mill scale. The total mill scale of the 24 logs between 13 and 20 inches was 3,159 board feet. The scale by the Vermont rule was 2,709 board feet, or 86 percent of the mill scale; by the Doyle rule 2,223 board feet or 70 percent of the mill scale; by the Champlain rule 3,089 board feet or 97 percent of the mill scale. While the results by the Vermont and Champlain rules do not vary appreciably when used on small logs, there is a distinct difference when applied to large logs. The Champlain rule is, therefore, much the more accurate for all purposes.

UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL
EXPERIMENT STATION
BURLINGTON, VT.

BULLETIN No. 188

APRIL, 1915

Forest Planting in Vermont as an Investment

BURLINGTON:
FREE PRESS PRINTING COMPANY,
1915

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University farm and buildings are on the Williston road, adjoining the University grounds on the east.

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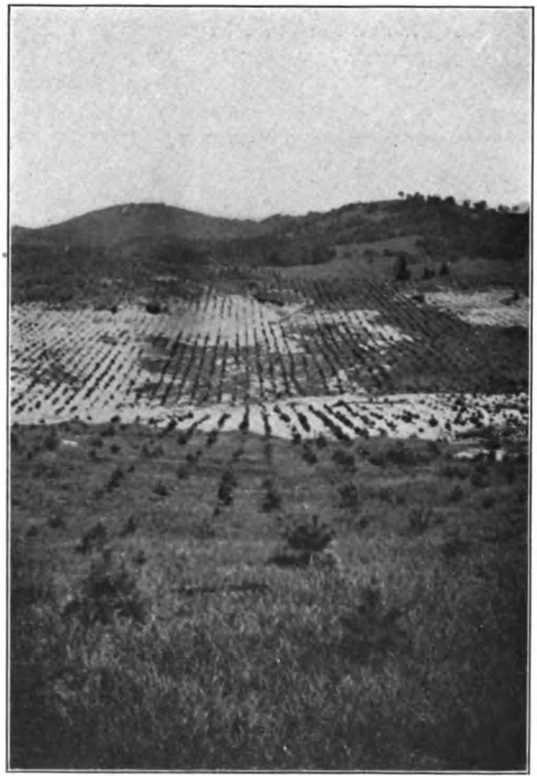
*In cooperation with Bu. An. Ind., U. S. Dept. Agr.

Plantation of White Pine on the Chas. Downer State Forest, Sharon, Vt.

Fifteen-year-old plantation of White Pine made by Prof. L. R. Jones in South Burlington, Vt.

Plantation of Scotch Pine, five years old, Sharon, Vt.



Plantation of Scotch and White Pine on bare sand, Lyndon State Forest, two years after planting.

BULLETIN 188 FOREST PLANTING IN VERMONT AS AN INVESTMENT

By A. F. Hawes, State Forester

Vermont Forestry Publication No. 17

Suggestions for the Prospective Forest Planter

1. A forest needs no fertilizer and very little care.
2. Taxation on forest plantations in Vermont is limited by law.
3. Only a rich man can afford to own unproductive land.
4. One acre of planted pine will produce a car load of lumber in 35 years.
5. A manufacturer can grow pine lumber for much less than he can buy it by the time it is grown.
6. A good growing forest often helps to sell the farm.
7. You can take a look at your forest plantation every Sunday, but you wouldn't know much about Wall Street if you camped there all summer.
8. If in doubt about planting, ask someone in your neighborhood who has tried it. The State Forest Service will send a complete list of Vermonters who have planted its trees.
9. The proceeds from one acre of pine plantation 45 years old would support a one-room school a year. If a town planted 45 acres, taxes for one school could eventually be eliminated.
10. In 1914 the State of Vermont spent about $370,000 for highway improvement. If the state owned ready to cut 1,250 acres of 40-year old pine plantation, the income would be sufficient to meet this expenditure. With 50,000 acres planted to forests 1 to 40 years old, taxation for state highway purposes at the present rate could be eliminated.

LAND WHICH SHOULD BE REFORESTED IN VERMONT

The United States Census shows that the total area of forest and waste land in Vermont is 3,719,000 acres, or 64 percent of her total area. It is impossible to say how much of this is covered with growing timber and how much is non-productive.

Abandoned pasture. Much land formerly used for farm purposes has been allowed to revert to a wild condition during the past generation. While some of this land can be reclaimed for agriculture, the expense is so great that only the best land is worth reclaiming. Much is seeding up naturally with tree growth, but this process is slow and often non-economic because many poor species gain entrance, and because even the good species are too widely spaced to make good timber. It is not so much a question whether the owners of this class of land can afford to reforest it, as whether they can afford to pay taxes on unproductive land for a long term of years. Many Vermonters would be better off if they gave away the unproductive part of their lands. The new tax law, described on page 294, offers an incentive to reforest this class of land.

Cut-over woodland. Thousands of acres of land formerly covered with timber, but which have been cut-over during the past quarter of a century, are coming up with a more or less worthless growth of trees and brush. Where fire followed lumbering, such land is often not worth paying taxes on. Even where it escaped fire it has been shown[1] that the growth of hardwoods which usually follows is a much less profitable investment to hold than the same land would be planted to pine. In other words, the profits from planting are enough greater than those from natural hardwood growth to make planting of this cut-over land a good investment, provided it can be protected from fire.

Openings in the forest. In most of our woodlots and forests there are non-productive openings which seriously deplete the profit from the timber. These should be reforested artificially if they are not seeding in with the valuable species.

Total area to be planted. Altogether it is safe to say that at least 20,000 acres should be annually reforested in Vermont for the next 40 years. This would call for an annual planting of about 24 million trees, as compared with less than a million now planted annually.

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[1] Vt. Sta. Bul. 176. (1914), Vt. For. Serv. Pub. 13.

Planting during the last few years. The state forest nursery was established by an act of the Legislature of 1906, and forest planting started on a small scale in 1908; but no extensive planting was done until the establishment of the State Forest Service in 1909. During the past 6 years the planting in Vermont has been as follows:

1909 and 1910	572,200 trees
1911 and 1912	1,010,700 trees
1913 and 1914	1,497,650 trees
	3,080,550 trees

While the chief value of these plantings is educational in directing land owners' attention toward other lines of forestry and bringing about more extensive planting, it represents a total area of about 3,000 acres planted. This in itself seems small compared to the total area in the State which should be planted. If plantations were no more productive than natural forests, the actual results in lumber would be insignificant. But as every one realizes that a cultivated potato patch will produce more than one left to itself, so it must be remembered that a forest plantation is much more productive than a forest which has seeded up of itself. A pine plantation 40 years old will produce an average of 25,000 feet per acre, and one 50 years old will produce 37,000 feet per acre. The area already planted, therefore, may be expected to yield by 1954 about 75,000,000 feet, or by 1964 about 111,000,000 feet. At $10 per thousand feet, this means a stumpage value of $750,000 and $1,110,000 respectively. Allowing 17,000 feet of lumber as the average load of a freight car, the lumber produced from these plantations would fill a freight train of 4,400 cars. If it were all shipped to New York and Boston it would bring to the railroads in freight rates about $200,000; whereas, if it were all used in Vermont it would have an employment value from the stump to the finished product of from $2,500,000 to $6,000,000 according to its uses.

Success of plantations. Most of the forest plantations set out in Vermont during the past few years have been successful and have given satisfaction to their owners. In the great majority of cases fully 80 percent of the trees planted have lived through the first year; in many cases over 95 percent. In practically all cases where less than 70 percent have taken root "there's a reason." In a few of these the trees have not been delivered promptly, either through fault of the express companies or neglect of the purchaser to send for them. In several cases the trees have been carelessly planted. One man distributed trees every six feet on the ground and several hours later sent a crew to plant them, an exposure which of course, was fatal. In a few cases plantations have been damaged by fire or grazing. After all, the best indication that the plantations have given satisfaction is the fact that many land owners have continued planting from year to year.

LIST OF OWNERS WHO HAVE PLANTED DURING 6 DIFFERENT YEARS

Name and address	Trees	Name and address	Trees
Charles Richardson, Brattleboro,	16,000	T. D. Hobart, Berlin,	48,000
Dr. Wm. S. Stevens, Enosburg,	213,000	J. J. Parker, Sharon,	6,100
P. J. Farrell, Swanton,	4,500	F. E. Spellman, Springfield,	16,500

LIST OF OWNERS WHO HAVE PLANTED 4 DIFFERENT YEARS

Name and address	Trees	Name and address	Trees
E. B. Barrows, Brattleboro,	9,000	Hon. O. L. Martin, Plainfield,	10,500
A. L. Powers, Woodstock,	40,500	Scott Farm, Dummerston,	57,000
B. H. Lamb, Sharon,	4,300	C. C. Putnam & Son, Middlesex,	32,500
Burt Bros., Stowe,	20,000		

LIST OF OWNERS WHO HAVE PLANTED 3 DIFFERENT YEARS

Name and address	Trees	Name and address	Trees
Hon. E. S. Brigham, St. Albans,	2,000	A. A. Priest, Randolph,	10,000
C. A. Ricker, Groton,	10,600	Holden & Martin, Brattleboro,	35,000
L. C. Croft, Clarendon,	5,000	Bridgewater Woolen Co., Woodstock,	71,000
E. S. Stearns, Lincoln,	12,000	A. B. Morgan, Woodstock,	10,000
Hon. T. N. Vail, Lyndon,	26,000	Dr. W. L. Wasson, Waterbury,	10,000
Newton and Thompson, Brandon,	41,700	J. O. Cannon, Rochester,	34,000
Miss Mary Woodbury, Weathersfield,	25,200	W. D. Woolson, Springfield,	63,300
Miss C. Vaughan, Thetford,	5,000	Mrs. E. J. Sherman, Windsor,	5,000
Hon. D. T. Hanley, Milton,	14,500	A. B. Finney, Sharon	3,500
E. L. Bass, Bethel,	2,200	City of Montpelier, Berlin,	75,000

Of the earlier state plantations, those made at Sharon in 1910 are the most satisfactory. Plantations of three-year white pine transplants made the same season in the same way on this and the Plainfield forest, show great variation in results. About 95 percent of the trees on the Charles Downer state forest at Sharon, and about 65 percent of the trees on the L. R. Jones state forest at Plainfield, were alive in 1914. The chief factor which caused the relatively unfavorable outcome at Plainfield was apparently the strong grass growth, causing excessive transpiration of moisture and damage by grubs. Greater care should have been used on this site in removing the sod at the time of planting.

Of the three species of pine planted in 1910 at Sharon, the white and Scotch pine have thus far grown considerably better than the Norway pine. On this light loam soil the white pine has grown even better that the Scotch pine, a great many trees having increased over thirty inches during the past year. This experience is unlike that secured in the state plantations at Lyndon, and on forest lands owned by the University of Vermont in Burlington and South Burlington. In these locations, which are on sandy soils, the Scotch pine has considerably outgrown the white pine planted beside it.

Plantations of Norway spruce made on upland pastures at Sharon and elsewhere in grass, have not been very successful; while those made by Dr. Wm. S. Stevens, and Mr. T. D. Hobart and others, on moist land where there were more ferns than grass, have met with very good success.

SAFETY OF AN INVESTMENT IN FOREST PLANTING

Two things must be considered in regard to any investment: probable profit and safety.

It is often suggested that substitutes will be introduced for lumber, and it is probably true that the maximum prices which lumber will command, in the future, will be regulated by competition with other materials. It can be said, however, that with all the recent substitutes introduced the utilization of lumber and wood has increased in United States even more rapidly than the population. While it is likely that substitutes will take the place of lumber for certain purposes, it is very doubtful whether a sufficient variety will ever be invented to reduce materially the many demands made upon a lumber like white pine, which is used for so many purposes.

It is also claimed by some that so many men plant pine that there is likely to be an overproduction of this kind of lumber, as compared with hardwoods. The numerous uses of softwood, especially pine, will probably always make the demand for this wood exceed that for hardwoods, as it does at present. There will be, for a great many years, more land mismanaged, which will naturally reproduce with hardwoods, than well managed: and the amount of pine raised in all the plantations made will be insignificant for a great many years, as compared with the demand, as is readily seen from the fact that the country uses annually 3,138,227,000 board feet of white pine, and in all 30,526,416,000 feet of softwood lumber, or 78 percent of the total production.

The chief danger to an investment in forest planting is, of course, through forest fire. In this regard Vermont offers the best opportunities for safe investment of any of the eastern states, since her fire risk is less. During the six years, 1909 to 1914, inclusive, the total area burned in Vermont was 16,346 acres, an average of 2,725 acres a year. This area annually burned over is 0.09 percent of the wooded area of the state, as compared with 0.2 percent in New York, 0.24 percent in Maine, 1.5 percent in Massachusetts and Rhode Island, and 2.3 percent in New Jersey. In other words at this rate it would require 1,111 years to burn over the wooded area of Vermont, as compared with 500 years in New York, 417 years in Maine, 66 years in Massachusetts and Rhode Island, and 44 years in New Jersey.

Forest fire risk in Vermont, with the present organization, is not sufficiently great to deter anyone from planting except in particularly dangerous situations. The only reason that it is considered a serious obstacle is that the bad fire years of 1903 and 1908, before the Forest Service was organized, are fresh in the minds of most people, and because they read of the serious fires in other states. It should be said in this connection, however, that the conditions favoring fires in some sections of Vermont are steadily growing worse because of the extensive slash made by large lumber operations, and it is only by maintaining an efficient fire service that the present low risk can be maintained.

There is no other serious risk in connection with forest planting. Much damage may be done by live stock in the first years of a plantation, but this is easily eliminated by fencing. In some localities damage may be done by deer. There have been a few instances of deer browsing on planted pine, especially the Scotch pine. As deer will not be allowed to multiply greatly this is hardly a serious risk.

Insects and fungi are likely to do some damage, but probably no greater, if as great, than in the case of agricultural crops. They should not deter anyone from planting, except in the case of some species which are particularly susceptible to such damage.

KIND OF TREES TO PLANT

In deciding upon species to be used in forest planting, the forester considers three points:

(a) Like the lumberman, he considers first the price which the different species may be expected to bring. Woods bring the highest prices which have some special quality which recommends them for special uses. The woods in Vermont which today bring the highest prices, are: white pine, because of its straight even grain, softness, and the ease with which it is worked; white ash, because of its bending qualities; basswood, because of its evenness of texture, freedom from defects, &c.; and oak, because of its strength and ornamental graining. Such woods as hemlock, fir and beech would not be recommended on this basis.

(b) The forester also considers a point not taken into account by the lumberman, viz.: the rate of growth. If one is engaged only in manufacturing lumber he naturally does not care how long it took the trees to grow; but if one is engaged in growing timber he is as much interested in the rate of growth as in the price at which the lumber will sell. In Vermont the native trees of most rapid growth are white and Norway pine, balsam fir and poplar. Trees whose slow growth discourage planting are the native spruce, hemlock, beech, birch and maple. A few foreign trees are recommended because of their rapid growth, such as the Norway spruce, European larch and Scotch pine.

(c) He considers in the third place the enemies which damage the different trees. White pine, for example, is recommended for the first two reasons, but is seriously damaged by the weevil,[1] pine blight and the blister rust disease. While Scotch and Norway pine are not specially valuable, they are much more apt to be free from disease. One of the chief objections to the planting of oak is the fact that its foliage is a favorite food of the gipsy moth, which is almost sure to gain entrance into Vermont within a few years. The black locust would otherwise be well worth planting were it not for the locust borer.

Taking these various factors into consideration, the following trees are especially recommended for planting in Vermont: white pine, red or Norway pine, Scotch pine, European larch, Norway spruce, white spruce, balsam fir, white ash.

THE WHITE PINE—*Pinus strobus*

The white pine has been the chief tree advocated for planting in New England, because it thrives on dry sandy soils, as well as on the better classes of soils, because it grows very rapidly, and because it makes a soft workable wood which is in great demand. This ability of the white pine to grow on practically all soils recommends it highly for general use, but it prospers best where the soil is fairly deep, moist and loamy. The heavy clay lands of Addison county originally bore extensive pine forests, as the old stump fences still demonstrate. Its root system is not large and there is no well developed taproot. The large topped trees grown in the open have a more extensive root system than the small topped trees of a close stand.

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[1] See p. 281; also Vt. Sta. Bul. 156, (1911), Vt. For. Serv. Pub. 4.

The action of light on the chlorophyll of the leaves is necessary to enable the leaves or needles of a tree to absorb carbon dioxid from the air. The carbon thus obtained, combined with water taken in through the roots, is the chief element of wood. The growth of a tree depends, therefore, not only upon the fertility and moisture of the soil, but upon the amount of light available for the leaves. White pine requires more light than the spruce, hemlock and maple, but less than poplar, white birch, tamarack and red pine. The trees requiring least light also cast the heaviest shade. Pine seedlings will live for years under the moderate shade of poplar and birch, but will soon die under spruce and hemlock. The light shade during the first few years may be a benefit in case of very hot, dry weather, but should be removed in a cleaning after the pines have become well established.[1]

On the whole the white pine is the most rapid growing tree of New England. Although individual specimens of other species may grow as fast, acre for acre pine will produce more lumber than any other species. A height growth of three feet a year is sometimes found on young trees, and a diameter growth on older trees of one inch; however, these figures are above the average.[2]

The great demand for white pine is due to the softness of the wood which makes it easily worked. For some purposes, as in the manufacture of matches, small boxes, &c., where short pieces can be used, the white pine is unequalled because of the fact that its branches grow in whorls and knots can therefore be discarded with very little loss. The greater the growth of the tree the longer is the clear piece of lumber available. For this reason white pine, grown on rich loam soils, will probably bring a particularly good price as the market becomes more specialized. In close stands the limbs die out younger and the knots are consequently smaller. The wood formed outside of these knots is perfectly clear. For these reasons a mixture of some deciduous tree, which casts a shade and breaks off the dead branches, may bring about a better grade of lumber; but the increased price thus secured for lumber would probably not make up for the deficiency in yield over that produced by a pure pine forest.

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[1] Vt. Sta. Bul. 156. (1911), Vt. For. Serv. Pub. 4.
[2] For tables of growth see Appendix.

White pine may safely be planted on any soil in Vermont up tc an elevation of 1,500 feet or northerly exposures, and 1,800 feet on southern and western exposures. On the better classes of soils, as those having considerable depth and mixture of loam, a spacing of 6 feet each way, giving 1,200 trees per acre, is sufficient. On the very dry, thin and sandy soils, a spacing of 5 by 6 feet is recommended, requiring 1,500 trees per acre.

Three-year transplants will usually be found most satisfactory, especially where there is any grass or brush growth. On worn-out pastures free from sod, two-year seedlings may be used with fair success. Three-year seedlings have no advantage over those a year younger.

RED OR NORWAY PINE[1]—*Pinus resinosa*

This tree derives its name from the fact that it was first noticed near Norway, Maine. It is native, although not common, throughout northern New England, and is found scattered over Vermont, as on the shores of Lakes Memphremagog and Champlain, Island Pond, Barnet Pond, on the Ottaqueechee near Woodstock, and elsewhere. In mixture with white pine its growth, for the first thirty years, is the more rapid of the two.

The main advantages of the red over the white pine lie in the fact that it makes a better growth, especially on poor soils, prunes itself of branches earlier, is more hardy, and is less subject to injury by insects and fungi. It withstands a range of temperature of from — 50° F. to +105° F., and thrives in sections where there are frosts every month of the year. It is usually found on soils where there is considerable sand and gravel, and for such soils, entirely lacking in clay or loam, is undoubtedly preferable to white pine for planting.

The Norway pine has a well developed tap-root when young, and develops strong laterals, so that it is usually very wind-firm. For this reason it may be planted not only where the soil is thin but on exposed sites. It is somewhat more exacting as regards direct sunlight than the white pine. Seedlings require direct sunlight and should not be planted in small openings of a forest or under any trees. It has been found, however, that Norway pine seedlings will stand sun exposure and weeds much better than will those of white pine.

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[1] Hawley & Hawes, Forestry in New England (Wiley); Woolsey & Chapman, Norway Pine in the Lake States, U. S. Dept. Agr., Bul 139. (1914).

Norway pine produces seed only once in 3 to 5 years. The cones are small and usually not plentiful, so that the seed is comparatively expensive. The young seedlings are particularly susceptible to damage by damping-off, and for these reasons nursery stock is usually more expensive than that of white or Scotch pine. Trees begin to produce seed at the age of about 25 years. Where the soil has been cleared of leaf litter good reproduction of this species is often secured 300 yards distant from seed trees, but the seed seldom germinates on a leaf litter.

After the seedling stage the Norway pine is remarkably free from enemies. On account of its thicker bark, it resists fire better than white pine, although young trees are, of course, killed by a hot fire. It is seldom attacked by the pine weevil and misshapen trees are very rare. It it also safe from the white pine blister-rust disease, and for this reason is recommended for planting in proximity to white pine suspected of being thus diseased.

While the wood of the Norway is somewhat redder in color, heavier and more resinous, it is sufficiently light, soft and straight grained to secure practically the same prices as white pine lumber. The wood is somewhat the stronger of the two. It is chiefly used for dimension stuff and house construction, also for boxes and shingles. Norway pine stumpage of old growth has sold as high as $12 per thousand feet on a national forest in Michigan. In Vermont it is seldom separated from white pine. Second growth stumpage has sold for $8.50 per thousand feet by the Champlain rule.

Norway pine should be planted pure, unless some slow growing tree which withstands shade is planted in mixture for the purpose of enriching the soil. The hemlock or native spruce could well be used in this way. When planted pure the trees should be spaced not nearer than six feet each way, since good pruning should be secured in this way. Three-year transplants are preferable, although two-year seedlings may be used where grass and weed growth is lacking.

SCOTCH PINE—*Pinus sylvestris*

This tree, which has been extensively planted in the eastern United States, is native throughout Europe, where several varieties are distinguished. It is common in Sweden and Russia and reaches an elevation of 2,700 feet[1] in the Vosges Mountains of eastern France, and of 6,000 feet in the Maritime Alps and the Pyrennes.

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[1] Cannon, D., "Semer et Planter," Paris (1894).

Although it will grow on the driest and most acid soils, as well as on those rich in lime, it thrives best, like all other trees, on more favorable sites. There are probably few soils in Vermont too poor for this species up to an elevation of 2,000 feet. The Scotch pine has a strong root system, forms a dense crown cover, and is able to compete with practically all kinds of brush growth which it soon outgrows and smothers.

It has been established in Europe that the three trees which do the most to enrich the soil are beech, hornbeam and Scotch pine; hence this is a splendid species for reforesting worn-out and badly managed soils.

Its strong root system which enables it to monopolize the soil makes it disadvantageous to plant it in mixture with other species. Experimental mixtures with white pine have been made at the state forest in Sharon, but usually it should be planted pure.

The growth of the Scotch pine is very rapid after it becomes established, surpassing the white pine on very sandy sites. On the better loam sites the white pine grows about as well. The leaders of the Scotch pine sometimes make a growth of 40 inches, and often between 2 and 3 feet.

The quality of the wood is said to be best in the north of Europe, while in New England it can be compared fairly well with the native red or Norway pine. The wood as a fuel is in great demand by European bakers; it is also used for paper pulp, mine props, telegraph poles, railroad ties and for general building purposes. In France the lumber is considered superior to that of the American white pine.

Either two-year seedlings or three-year transplants may be safely planted on most lands. The latter should be used in competition with brush growth, but on open lands the former may be safely planted, being considerably stronger than two-year white pine seedlings.

The same spacing may be recommended as for white pine, but as the Scotch pines will usually be planted on the poorest sites, a spacing of 5 by 6 feet will be usually adopted.

EUROPEAN LARCH—*Larix Europoea*

While similar to our tamarack, this tree has some advantages over, and some characteristics somewhat different from, its American relative. Unlike the tamarack it prefers a well drained, although not a dry, soil. In the Alps of France and Italy it reaches an elevation of 3,000 to 6,000 feet,[1] and may, therefore, be classed as essentially a mountain tree. So long as the soil is sufficiently deep and drained the larch will thrive, even if the soil is acid. In Europe it reaches a height of 100 feet and seems to live longer in mixture with spruce or fir. A mixture with deciduous trees is also good for soil protection.

The larch is fully as intolerant of shade as the tamarack and should only be planted in mixture with trees which it can outstrip. In a mixed stand in Connecticut where larch and pine are of the same age, the larch are taller, but the pine are somewhat larger in diameter.

The wood is so resinous that it is very durable in air and water. In Europe it is much used in boat making and for ties and poles. The best grades of wood are grown on northern slopes.

Two-year transplants are recommended for planting. They must be planted very early in the spring before the leaves begin to come out.

NORWAY SPRUCE—*Picea excelsa*

The Norway spruce, like the Scotch pine, is native throughout northern Europe, but is not peculiar to Norway any more than the pine is to Scotland. It is distinctly a mountain tree, occurring in the French Alps as high as 6,000 feet. However it thrives not only on thin mountain soils but also on the plains, provided the soil is not too dry. It grows more rapidly than our own red spruce and the lumber is apparently as good. It is much in demand in Europe, not only for general construction purposes but for such special uses as the manufacture of musical instruments. Wood fit for this work is only found in the mountains. Trees 130 feet high are not uncommon in France. One of the best plantations of this species in this country is that of the Billings' Estate at Woodstock, Vermont, now 36 years old. Tests of the wood of these trees, made by the International Paper Company, showed that it made a whiter and stronger pulp than our native spruce.

This species is well adapted for planting in Vermont on any sites which are not too dry, up to an elevation of 2,500 feet. It can be especially recommended for planting openings in the forest, because a certain amount of shade does not interfere with its growth. On worn-out farm lands it is easily killed out by strong grass growth in dry seasons.

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[1] Cannon, D., "Semer et Planter," Paris (1894).

There are two objections to the Norway spruce. One is that in New England it does not seem to live much more than 50 years. This is not a serious objection from the standpoint of raising pulp, since an excellent crop may be secured in 30 to 40 years. The other objection is that it does not reproduce itself well. Although it seeds plentifully, seedlings in the neighborhood of old trees are rare. The tree has the same reputation in Germany where it is largely propagated by planting.

The young plants are very susceptible to the scorching influence of sunlight and for that reason planting on southern exposures should be done in the early fall, so that the trees may become established before encountering hot weather. On wet or cold sites, on the other hand, spring planting should be adopted. A spacing of 5 by 6 feet may be recommended, requiring 1,500 trees per acre. Only three or four-year transplants should be used.

WHITE SPRUCE—*Picea Canadensis*

This tree, which is native in northern Vermont, is one of the common and valuable timber trees of Canada. It has never attained importance with us, although it has been considerably planted for ornamental purposes. Its rapidity of growth and the fact that it is native recommend it for planting on sites similar to those recommended for Norway spruce. It is believed that its lumber is nearly if not quite as good, and that its reproductive capacity is much better.

Three-year transplants should be used, and planted 5 by 6 feet.

BALSAM FIR—*Abies balsamea*

The balsam fir is undoubtedly a tree which will be more appreciated in the future than it has been in the past and which may be recommended for planting under certain conditions in Vermont.

It is one of the most northerly trees of the continent, being confined to regions where the average summer temperature does not exceed 70° F.[1] It reaches its best development in Maine where there is an average rainfall of 43 inches. In Vermont it is found chiefly in the northeastern counties, but it follows the upper slopes of the Green Mountains south the whole length of the State. Conditions of moisture and temperature are often similar in swamps and on the upper mountain slopes, and the ground in both cases is apt to be covered with sphagnum moss. On the mountains, however, the fir, like other trees, does not attain as large size as at lower elevations.

The balsam fir is short lived and consequently never reaches the proportions often attained by spruce. Trees 2 feet in diameter and 90 feet high are rare, although occasionally found on the lower slopes in Vermont. The foliage persists from 8 to 13 years, considerably longer than that of white pine. The root system is shallow, being similar to that of the spruce. The lateral roots extend out in all directions a distance of 5 feet or more.

Fir cones ripen in one year, while those of pine require two growing seasons. Ordinarily the tree begins to seed when 20 years old and the size of a good Christmas tree, but seed is more plentiful as the trees advance in age. The dominant trees, or those in the open, produce more seed than those crowded in a forest. Good seed years occur at intervals of 2, 3 or 4 years, according to the locality. The seed requires more moisture for germination than spruce, and where moisture conditions are suitable they germinate freely on rotten logs, mineral soil, moss, or even on hardwood leaf litter. In pure stands of balsam there are often from 200,000 to 300,000 seedlings to the acre.

The balsam requires less light than tamarack, white pine and arbor-vitae, but more light than either spruce or hemlock. Small dead firs under heavy shade are much more common than dead spruce. It will live under shade the first few years, but requires more light as it develops.

For good development the balsam requires a richer and moister soil than spruce. It reaches its largest size on flats where the soil is a moderately moist, deep loam. In wet swamps with acid soils and on pure sand it grows very slowly.

The balsam is particularly apt to be attacked by fungi which cause its decay and death at an early age. Because of rot this tree is much more apt to be broken off by wind than to be uprooted, as is the spruce. It is also especially susceptible to injury by fire, since the cambium is but slightly protected by the thin bark.

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[1] Zon,—Balsam Fir. U. S. Dept. Agr., Bul. 55 (1914).

The balsam is a fairly rapid growing tree, though not as much so as the white pine. During the first 5 years its height growth is much slower than that of pine or Norway spruce, but from that point onwards until 60 years old, it averages, under favorable conditions, nearly a foot a year. Crowded in a forest its growth is somewhat less. The most rapid diameter growth is between the ages of 20 and 70 years, during which time it requires an average of 9 years for one inch of growth on the radius.

Balsam fir is used both for pulp and lumber. Because of its pitch content it is inferior for pulp purposes to spruce. Most pulp mills in the northeast now use balsam up to 40 percent mixed with spruce. For lumber purposes it is customary to sell balsam with spruce and there is usually no difference in prices, except for first grade.

Altogether there is considerable reason for planting balsam fir on cool, moist sites in Vermont, especially at elevations where white pine would not prosper. Three-year seedlings or four-year transplants should be used, and should be planted 6 by 6 feet.

WHITE ASH—*Fraxinus Americana*

This tree is scattered throughout the hardwood forests of Vermont but seldom forms pure stands. It prefers a moist, deep loam soil and is almost never found on dry, sandy sites. When grown in proper situations and with sufficient light, the white ash grows fairly rapidly.

Its seed production is prolific and natural reproduction near old trees is usually good, especially on a mineral soil rich in humus; but in most cases the seedlings die out for lack of light within a few years.

Ash lumber is in great demand for uses requiring bending qualities, and the best grades bring very high prices, e. g. $22 per thousand for logs delivered. Stumpage brings from $10 to $12 per thousand.

It is a very easy tree to plant successfully and may be recommended especially where hardwoods have been cut clean. Two-year transplants should be used, and when planted pure should be spaced 5 by 5 feet, requiring 1,700 trees per acre. On cut-over lands where there is some brush growth, or where a tolerant species like spruce is planted in mixture, white ash may be planted 6 by 6 requiring 1,200 trees per acre.

METHODS OF PLANTING

As most of the failures in forest plantations have been due to careless planting, it will be worth the while of the prospective purchaser to pay special attention to this section. The mattock or grub hoe is the best planting tool. Three methods of planting may be described.

(*a*) *Common method for planting 2 or 3-year nursery stock on worn-out farm land, or cut-over woodland, known as the cleft method.* The sod is first scraped away from a space about 1 foot square, then the mattock blade is buried, the handle raised and twisted to the right, making a hole at the left side of the blade. The roots of the seedling are distributed carefully in the hole under the blade. The blade is then removed and the soil is pressed with the foot firmly about the roots, so that there will be no air spaces. Care should be taken not to expose the roots to wind and sunlight before planting, since 5 minutes exposure is often enough to kill them, and to see that the trees are not planted deeper than they were in the nursery, since trees are often killed by burying.

(*b*) *Hole method.* In using four-year transplants or three-year seedlings, where the roots are long and irregular, greater care is necessary. After the sod is removed the earth should be taken out making a hole 6 or 8 inches deep and a foot in diameter. The roots are distributed in this hole, the tree being held carefully in an upright position. The fine soil is then replaced about the roots and the coarser soil on top pressed down as indicated in the preceding paragraph. In neither case is the sod replaced.

(*c*) *Furrow method.* In some cases, where strong grass land is planted to forest trees, as is sometimes done by water companies, the best way to insure the trees against competition with the grass is to plant them in furrows 6 feet apart across the piece. The planting in the furrows is done in one of the ways described under (*a*) and (*b*). Wherever stones are removed from the hole it is advisable to replace these on top of the soil around the trees to prevent evaporation.

CONVENIENT PLANTING CREW

For planting in the method described under (*a*), a crew of 4 or multiples of 4 will be found to be most efficient. Three of these men, equipped with mattocks, plant the trees, each following a straight line across the field, approximately 6 feet apart, sighting at stakes at the other end. The fourth man or boy carries the trees (the roots being covered with wet moss) in a basket or pail strapped over his shoulder, and he passes them out to the other three. Such a crew can plant from 2,000 to 4,000 trees a day according to the kind of land.

For planting in the method described under (*b*), a crew of 5 or 7 men is most efficient. With a crew of 7, 3 with mattocks, follow parallel lines, as in the previous case, and dig the holes, one man carries the trees and distributes them to the other 3 who plant them. This method is of course, slower. Such a crew will seldom plant more than 4,000 trees a day.

TIME OF PLANTING

There are two seasons in which forest planting can be done. Early spring planting usually gives the best results. Planting in the spring should begin as soon as the frost is out of the ground, for the reason that there is usually a dry spell in May or June. If the trees can be well established before such a time, a much larger percentage will survive. In 1913 the planting season began April 1, but usually in Vermont, the best time is between April 15 and June 1. Trees cannot be planted safely after they have begun to grow until the fall.

With some species, like Norway spruce on southern exposures, fall planting may be recommended. The chief point in its favor is that farmers are not quite as busy in the fall as in the spring, the highway work is not so strenuous and hence more men are available. On tracts where there is much planting to be done, fall planting doubles the length of time available. In Vermont the fall season extends usually from about August 20 to September 20.

Unpacking stock. The seedlings should be planted as soon as possible after arrival. If they cannot be planted at once they should be heeled in, near the site that is to be planted. A ditch, preferably under shade, may be dug, and, after the bundles are untied, the roots should be covered with earth in this ditch, shading artificially if necessary.

Puddling. Just before planting a thick mud should be made, preferably with a slight admixture of clay. A few hundred trees are taken from the box or ditch and their roots are dipped in this mud. These are then placed in a basket or pail and their roots covered with wet moss or cloth.

SPACING

Dense planting is desirable so that the trees will begin to crowd each other at an early age and automatically prune each other. They will also make a better height growth than if the tops are wide spread. Although European foresters have in the past planted more closely, the general tendency is now toward a spacing of about 6 feet. Better grades of lumber can undoubtedly be secured by planting more closely, but with our poor markets for material removed in thinnings a quick production of coarse material bids fair to be more profitable.

Experience with all kinds of forest has demonstrated that nature provides more trees per acre on poor soils than on the better sites. In other words, the crowding is so intense on good soils that fewer trees survive than on the poorer sites. Some species, which are more tolerant of shade than others, need to be more crowded in order to prune themselves. For these reasons we recommend a spacing of 6 by 6 feet, making 1,200 trees per acre, for the pines and similar species, on soils of average depth and richness. On the poorest soils, or with tolerant species like the Norway spruce, a spacing of 5 by 6 feet, making about 1,500 trees per acre, is recommended.

Spacing	Trees per acre	Spacing	Trees per acre
4 by 4	2,722	6 by 6	1,210
5 by 5	1,742	7 by 7	888
5 by 6	1,452	8 by 8	680

ESTHETIC PLANTING

Most of the plantations made in Vermont have been for commercial purposes, and the methods thus far described have had only commercial operations in view. As Vermont lands come more and more in demand for summer homes, forest plantations made upon esthetic principles will undoubtedly be valuable, and in many cases will very likely bring a price in excess of their commercial values. There is no question but that a natural forest is more beautiful than one which has been planted in straight rows. For esthetic purposes, therefore, a plantation should resemble as nearly as possible a natural stand. The trees should be spaced unevenly with some clumps and occasional openings. It is rather difficult to plant as many as 1,200 trees to the acre in this way. One of the best methods of planting irregularly is to scatter broadcast over an area as many pieces of wood as one wishes to plant trees. When the trees are set where these blocks fall there will be very few straight lines and the resulting forest will have a natural appearance.

PRICES OF NURSERY STOCK PER THOUSAND, SPRING, 1915

The prices of nursery stock for the present season are:

White pine	2-year seedlings[1]	$2.50
White pine	3-year transplants[1]	5.00
Scotch pine	2-year seedlings	2.25
Norway or red pine	3-year transplants	5.75
Norway spruce	3-year transplants	5.00
White ash	2-year transplants	8.00

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[1] Seedlings are raised in the seed-beds for one or two years and are then transplanted. A year after this transplanting they are called three-year transplants.

These prices are for trees packed and delivered to the express company, but do not include the cost of transportation.

The state nursery has no intention of competing with private nurseries, and, therefore, does not sell large ornamental trees. Neither are orders accepted at the above prices for less than 500 trees of any one kind. However, in order to interest land owners who have not hitherto undertaken forest planting, a special offer of a sample package is made during the spring of 1915 on the following terms:

A sample package may contain 250 three-year white pine or Norway spruce transplants, choice to be made by the purchaser. No mixed lots will be allowed. These packages will be sent by parcel post, postage prepaid. The price per package will be $2. This price is at a somewhat higher rate than for larger quantities, but it eliminates the necessity of driving to the express office for a small number of trees.

COST OF PLANTING

During the past 5 years the cost of labor has considerably advanced in Vermont, so that while nursery stock is cheaper the total cost of planting is as much, if not more, than formerly. The labor item for planting 1,000 trees on the state forests in 1913 was: Plainfield, $6.00; Lyndon, $4.23; Mendon, $5.12; Townshend, $5.15; Camel's Hump, $5.58. These prices included labor at $1.75 per day, and a foreman at $2.00 or $2.25 a day.

Estimating the average express charges as 25 cents per thousand, and the cost of hauling from the express office to the land at 10 cents per thousand, the cost of planting is as follows:

TABLE I. COST OF PLANTING 1,200 TREES PER ACRE

	Large plantations on fairly easy land, where labor costs $4 per thousand		Small plantations on difficult land, where labor costs $6 per thousand	
	2-year trees @ $2.50	3-year trees @ $5.00	2-year trees @ $2.50	3-year trees @ $5.00
Price of trees	$3.00	$6.00	$3.00	$6.00
Transportation	.40	.40	.40	.40
Labor	4.80	4.80	7.20	7.20
Total cost per acre	$8.20	$11.20	$10.60	$13.60

COST OF PLANTING 1,500 TREES PER ACRE

	Large plantations on fairly easy land, where labor costs $4 per thousand		Small plantations on difficult land, where labor costs $6 per thousand	
	2-year trees @ $2.50	3-year trees @ $5.00	2-year trees @ $2.50	3-year trees @ $5.00
Price of trees	$3.75	$7.50	$3.75	$7.50
Transportation	.55	.55	.55	.55
Labor	6.00	6.00	9.00	9.00
Total cost per acre	$10.30	$14.05	$13.30	$17.05

From the above examples it will be seen that the cost of planting an acre (with labor at $1.75) may vary from $8 for planting 1,200 two-year seedlings on easy land to $17 for planting 1,500 three-year transplants on brushy, rocky land.

There are forestry companies which make a business of planting by contract. Their prices for planting 5 acres or over with 1,000 three-year transplants per acre range from $13 per acre upward.

CARE OF FOREST PLANTATION

The most important thing in forest management is to furnish adequate fire protection. There are many tracts near railroads, or large lumber operations, where the danger is so great that forest planting is hardly justified. Whenever planting is done it is well to take measures for protection. Large plantations of conifers should be broken up into blocks of ten acres or less, either by plowed fire lines about one rod wide, or by planted belts of deciduous trees four rods or more in width. Plowed lines may be kept free from vegetative growth by harrowing two or three times a year. Belts of deciduous trees may be made more effective by annually raking up and burning the leaves and broken branches.

Stock should be excluded from plantations for at least eight years after planting. Cows do not eat pine tops but they break them off by rubbing againt them when the trees are 2 to 5 feet high.

Sometime within the first 6 years of the life of a plantation it is usually desirable to make a "cleaning." This consists in removing any brush or inferior trees which are crowding the more valuable planted trees. Poplar and birch are especially apt to damage young pine by rubbing off the terminal buds. Blackberry and raspberry bushes often retard growth by shading the young trees. It is not necessary to remove the injurious growth from the plantation, but it is often sufficient to break it off near the base. This can be done at comparatively slight expense.

In all plantations of white pine a careful inspection should be made every summer for the weevil until the trees are above its reach.[1] This insect seldom kills the tree but invariably works in the main shoot causing it to wither and die, usually in July or early August. The next year one of the side branches straightens up and forms the leader, but there is always a slight crook in the tree. In badly infested regions the same tree is often attacked repeatedly and the numerous crooks give it a much deformed and stunted appearance. Of course its value for timber purposes is much diminished. The insect seems to prefer trees from 3 to 30 feet in height, though it occasionally attacks tall trees. Its ravages are worse in the southern range of the species than in Vermont. The adult is a reddish-brown beetle about half an inch long with a pronounced snout. The pupa is creamy white and of about the same length as its adult. The grub is also white and of varying length up to one-fourth of an inch, according to development. The infested top is badly decayed at the close of the season and is cut up with tunnels filled with borings. The first sign of the attack is disclosed by the wilting of the needles. The beetles deposit their eggs under the bark of the main shoots in May or June, and when the grubs hatch after a week or two they bore inward and in a downward direction to the pith. The grubs are much reduced by natural enemies, mostly parasitic insects. They transform into pupae and adults and during July and August of the same year, when the adults are fully matured, they bore their way out and seek suitable places in which to pass the winter.

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[1] Vt. Sta. Bul. 159 (1911), Vt. For. Serv. Pub. 4.

The only way of fighting this insect is to cut off the infested top during June and July before the beetles have escaped. The safest way of destroying the weevils is to burn these tops; but as they often contain also a large number of minute insects which prey on the weevil a modification of this procedure has been suggested by Hopkins. A perfectly tight can is prepared with but one opening. The infested tops are placed in this can and the opening covered with a very fine wire mesh, so fine that the beetle cannot escape, whereas the parasites, which are much smaller, get out and attack other weevils. Either form of treatment must be repeated several successive years, as it is impossible to catch all the weevils in a single season.

TAXATION ON FOREST PLANTATIONS

No. 40 of the Acts of 1912 makes it possible for the owners of forest plantations and of young natural forests to determine in advance with some accuracy what the taxes are likely to be. Without knowledge of this kind one has little incentive to plant forests. This enactment and illustrations of its application follow.

AN ACT RELATING TO THE TAXATION OF YOUNG TIMBER

It is hereby enacted by the General Assembly of the State of Vermont

Section 1. An owner of land who wishes to classify the same under the provisions of this act shall make application for such classification to the state forester accompanied by such description of the land as the state forester may require. Application having been made in due form, the state forester shall examine the land in question, and if he finds the requirements hereinafter provided have been fulfilled, he shall issue a triplicate certificate of classification, the original to be filed in the office of the state forester, one copy in the office of the town clerk of the town in which the land is located, and one copy given the owner.

Sec. 2. Cut-over or other land fully stocked with forest trees not more than fifteen years old, except scattered trees the presence of which does not increase the assessed value of the property; cut-over or other land incompletely or partially stocked with forest trees not more than fifteen years old, when planted with a sufficient number of additional trees to assure a spacing of approximately six by six feet over the entire area; and open land planted with forest trees not less than one thousand to the acre; provided in each case that the trees planted are of the following species: ash, basswood, oak, maple, white, Scotch or Norway pine, European larch, white or Norway spruce, or any other species approved by the state forester, and also provided that said state forester approves the manner in which the trees are planted, and provided further that said land is outside the limits of a city or village, shall be classified as forest land, and shall thereafter be taxed annually at the local rate on a valuation of the land alone, said valuation to be established by the local listers at the time of classification, but in no case to exceed three dollars an acre, said valuation to be maintained until the year 1950. In the year 1950 the land alone shall be revalued without regard to the above limit, and the valuation then established shall be maintained for a further period of fifty years, tax being levied annually on said valuation at the local rate. Whenever a commercial cutting is made a tax of ten percent shall be levied on the gross stumpage value of the amount cut.

Sec. 3. Classification as forest land for purposes of taxation shall be continued so long as proper forest conditions are maintained thereon. Use of said land for pasture; destruction by fire of the tree growth and failure of the owner to restore forest conditions; removal of tree growth and use of land for other purposes; or any other changed conditions which, in the opinion of the state forester, indicates that proper forest conditions are not being maintained, shall be considered sufficient grounds for cancellation of classification. When requested by the town listers, or whenever he may deem it necessary, the state forester shall examine classified forest land, and if he finds that the provisions of the law are not fully complied with, he shall forthwith cancel the classification of said land, sending notice of such cancellation to the town clerk of the town in which the land is located, and the owner thereof. Said land shall thereafter be taxed under the laws governing the general property tax unless it be granted reclassification as forest land at a subsequent date. Whenever a classification is cancelled, the owner of the land shall be required to pay a tax on the stumpage value of the standing timber amounting to one-half of one percent per annum for the entire number of years that said land has been under classification. This tax shall be in addition to any annual tax or yield tax which may have been paid, or may be collectible.

Sec. 4. All products of cuttings on classified land shall pay a yield tax as provided in sections 2 and 3 of this act except material cut for domestic use and which is not to be sold, or material removed in the form of thinnings to improve the condition of the remaining stand, and whose stumpage value does not exceed the cost of removal. Whenever a cutting, other than excepted above, is made the owner of the timber shall file with the local listers and the state forester, a sworn statement of the quantity which has been cut, and its stumpage value. If either the assessors or the state forester deem the value as stated too low the state forester shall determine the stumpage value and report the same to the listers and the owner. Should the owner be unwilling to accept the valuation as given by the state forester, he may refer the matter to a special board consisting of the first selectman and the town clerk of the town in which the land is located together with the state forester, whose decision with regard to the valuation shall be final.

Sec. 5. Sections 368, 369 and 370 and subdivision XIV of section 496 of the Public Statutes shall apply only to land planted to forest trees prior to January 1, 1913.

Approved February 13, 1913.

A few illustrations of the manner in which this enactment operates.

1. A has a tract of 100 acres which is fully stocked with spruce from 1 to 15 years of age, which is now pastured. He wishes to have it classified. What must A do to have it classified; and what will his taxes amount to for the next 20 years?

He must agree to exclude all stock and make application for classification to the State Forester, who will have the land examined. If accepted, the land will then be assessed at not over $3 an acre, and probably at this figure. If the tax rate is two percent, i. e. $2 on a dollar, the annual tax on the land will be $6. This tax in 20 years would amount to $178.67 at 4 percent compound interest. If no cuttings were made during this period there would be no other tax.

2. B owns a tract of 200 acres, half of which is fully stocked with hardwoods from 1 to 15 years old; the other half is open pasture land. What must he do to have this land classified? What

would the tax on this amount to in 25 years if he removed 100 cords for his own use?

He can fence off the half which is fully stocked and apply to have this classified; or he may reforest the remainder and apply for classification for the whole area. If the whole area is classified at $3 an acre the total valuation would be $600. If the tax rate is 1.5 percent or $1.50 on the dollar, the annual tax would be $9. This tax at 5 percent compound interest for 25 years would amount to $429.54. There would be no tax on the wood cut since it is used by the owner.

3. C owns 300 acres which is partially covered with young trees from 1 to 15 years old. He wishes to make an improvement thinning in 20 years and another cutting in 30 years. What must he do to have the land classified and what would his taxes amount to?

In order to have it classified he must interplant so that the spacing will be approximately 6 feet over the entire area. If the land is valued at $3 an acre, and the tax rate is 1 percent or $1 on the dollar, the valuation would be $900 and the annual tax $9. At 4 percent compound interest this would amount in 30 years to $504.76. If he removes 1,000 cords in the thinning, which is worth on the stump $1,000 and it costs to remove the wood $1,500 there would be no tax on this wood. If at the end of 30 years he sells 500,000 feet of lumber, worth on the stump $3,000, his tax on this cut will be $300.

RETURNS FROM PLANTATIONS

The only way of forecasting the probable returns from a forest plantation is by means of yield tables. Unfortunately such tables have been made for comparatively few species. The following table for white pine gives conservative results for plantations, because it is based on natural, unthinned stands in New Hampshire.

TABLE I. YIELD TABLE SHOWING YIELD IN BOARD FEET WHICH UNIMPROVED NATURAL SECOND-GROWTH WHITE PINE HAS PRODUCED IN NEW HAMPSHIRE[1]

	Board feet per acre		
	Best pine soil	Medium soil	Poorest soil
20 yrs.	4,600	3,150	1,700
30 "	15,100	10,800	6,550
40 "	33,550	25,000	16,450
50 "	47,450	37,800	27,650
60 "	57,300	47,400	37,500
70 "	65,900	55,800	45,700
80 "	73,300	62,850	52,400
90 "	80,050	69,000	57,950

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[1] N. H. For. Com. Rpt. 1905-06.

TABLE II. MONEY YIELD TABLE—WHITE PINE

	Stumpage at $8 per M.		Stumpage at $10 per M.		Stumpage at $12 per M.	
Soil	Quality I	Quality III	Quality I	Quality III	Quality I	Quality III
20 yrs.	$ 36.80	$ 13.60	$ 46.00	$ 17.00	$ 55.20	$ 20.40
30 "	120.80	52.00	151.00	65.50	181.20	78.00
40 "	268.00	132.00	335.50	164.50	402.00	198.00
50 "	379.20	220.80	474.50	276.50	568.80	331.20
60 "	458.40	300.00	573.00	375.00	687.60	450.00
70 "	527.20	365.60	659.00	457.00	790.80	548.40

The following yield table for white ash was made by a study of individual trees, and is not, therefore, as accurate as the pine table.

TABLE III. YIELD TABLE FOR PURE WHITE ASH BASED ON THE MEASUREMENTS OF RAPID GROWING INDIVIDUALS

	Number of trees per acre	Volume per tree	Total volume per acre	Value of stand[1]
30 yrs.	160	90	14,400	$ 86.40
40 "	145	135	19,575	117.60
50 "	135	185	24,975	150.00
60 "	128	235	30,080	240.64
70 "	121	275	33,275	266.16
80 "	114	320	36,480	291.84
90 "	105	365	38,325	306.56

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[1] Value is based on a stumpage price of $6 per thousand board feet for stands under 55 years, and of $8 for older stands.

PROFIT FROM FOREST PLANTING

Table II indicates the probable financial returns from pine plantations of different ages on the best and poorest soils. In order to form an idea of the profit which these figures represent it is necessary to compute the cost of the plantation at these various ages. Table IV gives this data in three sets of figures based on an initial cost of planting of $8, $12 and $16 per acre respectively. It is assumed in these calculations that the plantation would be classified under No. 40 of the Acts of 1912, that the land would be valued at $3 per acre, and that the tax rate on the land is 2 percent. The investment in the land, cost of planting and taxes on the land are computed as 4 percent and the yield tax is based on an assumed stumpage value of $10 per thousand.

TABLE IV. COST OF PRODUCTION PER ACRE

	Cost of planting per acre					
	$8		$12		$16	
Soil	Quality I	Quality III	Quality I	Quality III	Quality I	Quality III
20 yrs.	$ 27.47	$ 24.59	$ 36.23	$ 33.35	$ 44.99	$ 42.11
30 "	51.10	42.59	64.06	55.55	77.02	68.51
40 "	89.03	71.96	108.25	91.16	127.45	110.36
50 "	181.83	111.99	160.27	140.43	188.71	168.87
60 "	184.30	174.50	226.38	216.58	268.46	258.66

Table V shows the profit which may be derived from one acre of forest plantation, stumpage figured at $10 per thousand feet, as displayed in Table II, and the cost figured at three different rates for planting, as given in Table IV. It will be seen, for example, that a plantation costing $12 an acre to form will produce in 50 years a profit of $314 on the best soil and $136 on the poorest soils over and above all costs, including taxes and compound interest at 4 percent.

TABLE V. PROFIT PER ACRE ABOVE 4 PERCENT COMPOUND INTEREST, CALCULATED FOR A STUMPAGE PRICE OF $10 PER THOUSAND FEET

	Cost of planting per acre					
	$8		$12		$16	
Soil	Quality I	Quality III	Quality I	Quality III	Quality I	Quality III
20 yrs.	$ 18.53	$ 7.59 (Loss)	$ 9.77	$ 16.35 (Loss)	$ 1.01	$ 25.11 (Loss)
30 "	99.90	22.91	86.94	10.05	73.98	3.01 (Loss)
40 "	246.45	93.54	227.25	73.34	208.05	54.14
50 "	342.67	164.51	314.23	136.07	285.79	107.63
60 "	388.70	200.50	346.62	158.42	304.54	116.34

Value of Land That Can Be Planted Profitably

The question often comes up as to how valuable land can be planted to white pine. Naturally the more valuable the land the lower rate of interest will be borne on an investment in planting. The table given below is based on a cost of planting of $12 an acre. As shown above, this is a liberal figure, for the cost is quite as apt to be below as above this amount. It is also based on an assumed stumpage value of only $8 per thousand, which is undoubtedly the minimum value especially for future calculations. If a larger value were assumed the percentage of profit would be correspondingly larger. However, under these conditions the table shows that land valued at $10 an acre, planted at a cost of $12 should yield 4 percent compound interest on the investment on the poorest soils, and on the best soils as high as 6 percent. On lands valued at $3 an acre a 7 percent profit should be realized in 40 years.

It should be realized that it costs practically as much to plant an acre of the poorest soil as of the best, but that the returns are very much less. It must be borne in mind that these qualities of soil do not refer to agricultural conditions, the best forest soil often being on a par with the poorest agricultural soil, since the forester does not contemplate using land for forestry which could more profitably be utilized for agriculture. Bearing these things in mind, it will be realized that a person contemplating an investment in forest planting will do well to study soil conditions, just as for farming, and invest his money in planting land which will produce the highest returns. He will see that whereas he may easily have a 5 percent investment on land costing $10 an acre, if the soil is productive, it would be impossible for him to derive such a profit from the poorest land, if it cost him more than $5 an acre. Tax listers should take these matters into consideration and list forest lands by a gradation of values according to their productive powers, in the same manner as with agricultural lands.

TABLE VI. PERCENTAGES OF PROFIT OBTAINABLE FROM WHITE PINE PLANTATIONS ON LAND OF DIFFERENT VALUES, WHERE PLANTING COSTS $12 AN ACRE, AND WHERE LUMBER IS WORTH $8 PER THOUSAND FEET ON THE STUMP

Age in years	Quality I				Quality III			
	Value of land per acre							
	$1	$3	$5	$10	$1	$3	$5	$10
	Percent				Percent			
20	4.5	4	3.5	3	0	0	0	0
30	7	6.5	6	5.5	4	3.5	3.5	3
40	7	7	6.5	6	5.5	5	5	4
50	6.5	6	6	5.5	5.5	5	5	4
60	6	5	5	4.5	5	4.5	4.5	4

In this connection the question naturally arises as to what is agricultural land and what is forest land. It must be admitted that there is no distinct line of demarcation. Much land in Vermont which was formerly profitable for sheep raising is today more profitable for timber production. The change is not so much due to the deterioration of the soil as to competition with Australia and other sheep raising sections, and to the growing scarcity of lumber throughout the United States. During recent years the number of cattle as well as sheep in Vermont has been steadily falling off. This has resulted in a diminishing demand for pasture and, consequently, a lowering of the profit derived from its use. True forest soil is the land which can never be used for agriculture; yet who can say what conditions a dense population of two or three centuries hence may bring about? All that we can hope to do is to predict for a period of 40 or 50 years what land can be profitably used for agriculture, and to advocate the use of the rest for forest production. Much land in Vermont is so steep, or rocky, or for other reasons unfavorable for agriculture, that it is practically certain that it will not be profitable for agriculture during the present century. Much of this land classifies as third quality forest soil and private owners should be conservative about investing money in reforesting it. It is chiefly a type of land which should be owned and reforested either by the state or town, since the indirect benefits to the community would repay public expense though they would not compensate an individual owner.

There are in addition to these true forest soils, large areas of Vermont land, some of which have been used for agriculture in the past, and all of which may be profitably thus used at some future time. Any of this land which can be profitably cleared up and used for farming should be so used; but land that is far distant from a market, or upon which the cost of improvement would be excessive, or which for other reasons is not adapted to farming in the near future should be used for forest production. If after the growing of one forest crop conditions have so changed as again to make farming profitable on this land, it will be found that the forest has considerably enriched the soil. In some portions of Europe such an alteration of wood and farm crops has long been recognized as a legitimate form of agriculture.

It is not, however, a simple matter to determine at present just what land can be profitably used for agriculture. A progressive farmer, with due regard to labor income, might get a profit from a tract from which another man, considering only yield per acre, might derive no profit. In the same way, some pastures which are now liabilities rather than assets could be turned into assets by proper management. However, in dealing with average conditions of land we must also deal with average abilities to handle the same, and the average profits now being derived from them. The best way of determining the income from a pasture is to ascertain how much rental it would yield, since that depends somewhat upon the local supply and demand of pasture.

Table VII shows the accrued income on pasture land figured at 4 percent, compound interest for periods from 20 to 60 years. Comparing these figures with those in Table V, one may ascertain the relative profit from pasturing a certain area and from planting to forests. For example, a net income of 25c an acre on pasture, over and above interest on the value of the land and taxes, amounts to $7.45 in 20 years at 4 percent compound interest. Comparing with Table V one finds that allowing $12 an acre as the cost of planting the profit in 20 years on the best soil is $9.77 per acre, and that on the poorest soil the loss is $16.35 an acre. For such a short period the advantage in this case would be in favor of pasture.

A net income from pasture of $1.00 an acre a year amounts in

40 years to $95 while the net income from a plantation costing $12 to establish ranges from $73 to $227 an acre. Evidently for such a long term a forest plantation is more profitable than pasturing even at a net income of $1 which is rather a high rental for the class of land which will usually be planted to forests.

TABLE VII. ACCRUED INCOME FROM PASTURE RENTALS

Age in years	Net income per acre per year			
	$ .25	$ .50	$ 1.00	$ 1.50
20	7.45	14.90	29.80	44.70
30	14.00	28.00	56.00	84.00
40	23.78	47.50	95.00	142.50
50	38.20	76.40	152.80	229.20
60	59.40	118.90	237.80	356.70

COST OF RAISING PINE LUMBER

In the preceding pages the probable profit from forest planting has been discussed from the standpoint of the man who is to sell his lumber. There is even greater incentive for the manufacturer who uses a large amount of lumber to raise his own. By so doing he is sure of a sufficient local supply in the future to enable him to continue his business, and he can determine in advance fairly accurately what this supply will cost him. Without such a supply he must purchase from different sources, paying whatever is the market price at the time, and probably having to pay the freight rates for a considerable amount of it. He should realize that land owners in the future will be more intelligent about the selling of lumber than at present, and that bargains in woodlots will be increasingly scarse.

The local supply of lumber is likely to have an increasing influence on manufacturing business. It will be more and more difficult to compete with concerns having a local supply of lumber to meet their requirements.

The following calculation was made for a Vermont manufacturer who uses 800,000 board feet of pine annually, to determine how much it will cost to raise this amount annually. From Table I it is seen that it is fair to assume a production of 30,000 board feet per acre in 40 years. To cut 800,000 feet one must have 27 acres of 40-year old plantations. In order to cut 27 acres a year for 40 years a total of 1,080 acres is required, or, approximately, 1,100 acres.

Cost of 1,100 acres of land at $3	$ 3,300
Cost of planting 1,100 acres at $10	11,000
	$14,300
Value of land, $3,300 at 4 percent compound interest for 40 years	$12,540
Cost of planting, $11,000 at 4 percent compound interest for 40 years	52,800
Tax of 1 percent on land value under No. 40, Acts 1912, at 4 percent compound interest for 40 years	3,135
10 percent yield-tax on stumpage, valued at $15 per thousand	49,500
Total cost of growing 32,000,000 board feet	$117,975
Average cost per 1,000 feet	$ 3.68

If pine stumpage sells for $15 per thousand at the end of 40 years, the manufacturer in question and his successors would save $11.32 on a thousand feet, or $9,056 annually. In the case of less productive land the cost of raising lumber would be correspondingly greater, as would also be the case, of course, if the land or the planting cost more than in the above example. On the other hand it is possible to improve upon all of these figures, though one is not likely to obtain first quality land for less than $3 an acre. If stumpage is worth less than $15 per thousand at the time of cutting, the yield-tax would be correspondingly less. With stumpage figured at $12 the yield-tax would be $38,400 instead of $49,500, the cost of growing would be $3.34 per thousand instead of $3.68, and the profit would be $8.66 per thousand instead of $11.32.

In both of the cases above cited the profit in raising stumpage is predicated on the supposition that the manufacturer could purchase plenty of lumber in his own locality at the market price. As a matter of fact this will very seldom be the case, unless the manufacturer at least furnishes an example sufficient to interest others in this form of investment. In estimating his profit from planting we should, therefore, add freight charges to the stumpage price of most of the lumber purchased for a large business. If a concern, such as the one mentioned above, is obliged to buy half of its lumber from a distance, the freight charges on the same may well amount to $1,000 a year, which must be added to the annual profit if the manufacturer raises his own lumber near at home.

In the sale of wood-using industries in the future a supply of available growing timber suitable for the future needs of a business will be a very important asset, and a wood-using industry which has no such supply will find itself very much handicapped as compared with those in the vicinity of extensive forests.

It is said that the stockholders of one of the large Canadian paper companies, who are mostly English, always inquire first as to the area of the company's lands reforested, before they look into the items of receipts and expenditures. The time will come in this country when stockholders will demand that their business be run on a permanent basis, and that an annual inventory be submitted, showing the exact condition of all lands owned. Inventories of this sort would not be valuable assets to most companies at present.

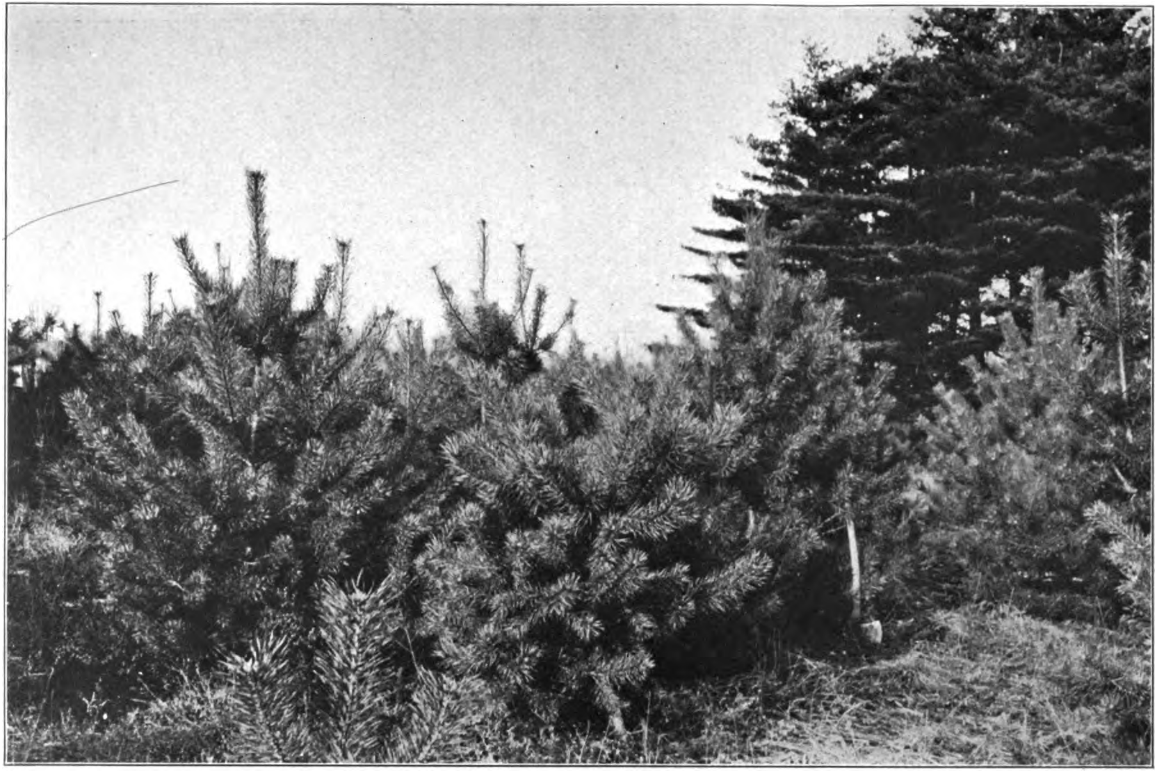
SCHOOL ENDOWMENT FORESTS

In several foreign countries municipalities derive a considerable portion of their revenue from municipal forests. A village or city, being a permanent institution, can forego immediate returns for greater future returns and is, therefore, well adapted to manage forest property. This management is also usually safeguarded from local political vagaries by placing it entirely under the direction of the central forestry department, although the money goes directly to the municipal treasury which has entire control of expenditures. As examples of such communal or municipal forests, the following may be mentioned, although they are by no means exceptional.

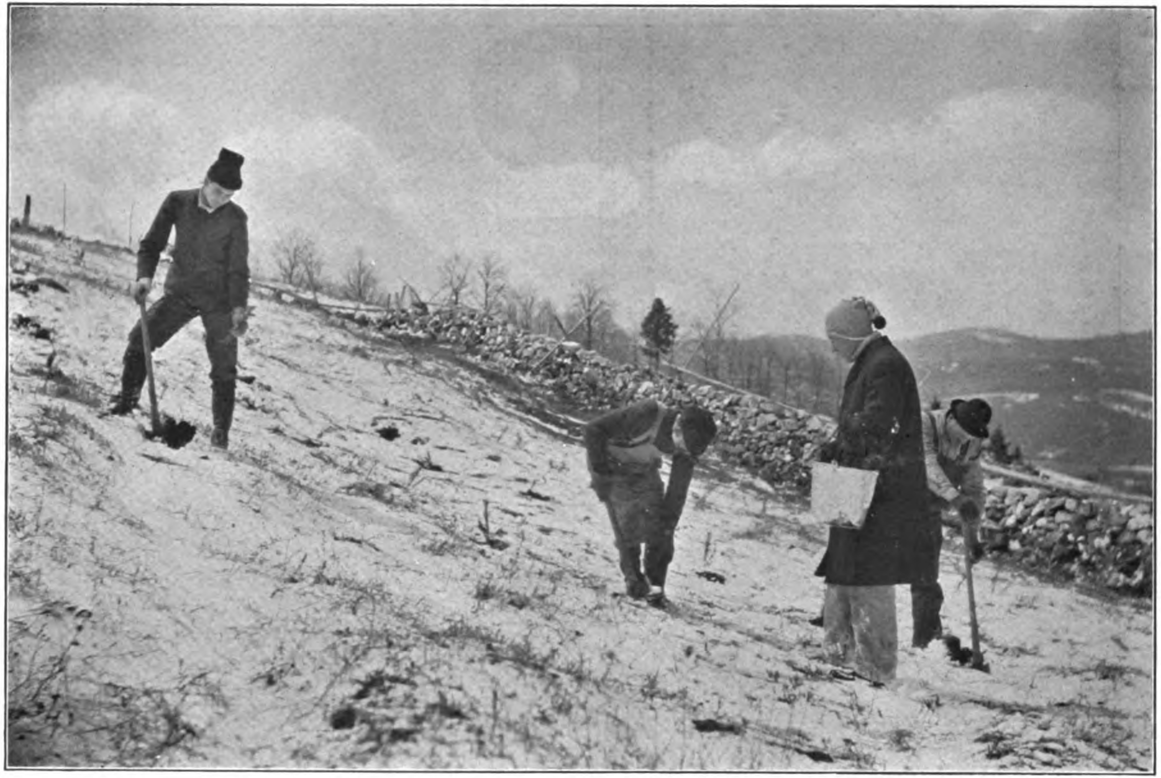
Forbach, Baden, with about the same population as the Vermont town of Bethel, enjoys an annual revenue of nearly $18,000 from its forest. Such a revenue would nearly eliminate taxation in Bethel.

It is often said that we cannot argue from conditions in foreign countries; but unless we admit that representative government is a failure there is nothing in this argument. Natural conditions here are equal to those in Europe. Our climate, soil and species of trees are as good or better than those in Europe. In fact, without much difficulty it can be shown that conditions for investing in forestry are better in New England at present than in Europe. While lumber is now worth about twice as much in Europe as with us, our prices are kept down by the immense supply of virgin timber in the west and by the fact that New England has no protective tariff, as has Germany. As soon as the virgin timber of the west is depleted, which will be before our present plantings are mature, our prices will be practically equal to those of Europe. In fact it is quite probable that the time is coming when lumber will be even more costly than in Europe. The city of Zurich, Switzerland, recently purchased about 1,700 acres to add to its forest, paying an average of $80 an acre for the land alone. Many other purchases at similar high figures might be mentioned. In New England, on the other hand, large areas can be secured for from $2 to $6 an acre. The State of Vermont recently purchased a tract of 3,000 acres, carrying a large amount of timber, for $3.25 an acre. When it is said that forest planting in Europe brings comparatively small interest on the investment it must be remembered that there is a great disparity between land values here and abroad, and that now is the time to make investments of this kind. From what has already been said as to the relative fire risk in Vermont and the rest of New England, it may be seen that the opportunity for safe and profitable investments in forest planting are as good in Vermont, if not better, than elsewhere.

Several attempts have been made recently to popularize the idea of municipal forests in this country, notably those of the Massachusetts Forestry Association. To the writer the great difficulty with this movement has been to bring the public to distinguish between parks handled for recreation, which they are accustomed to, and forests handled chiefly for profit, but also available for recreation. Few Vermont towns can afford the luxury of a large park, but many could well make a long time investment. The purpose of No. 24 of the Acts of 1915, is to provide for municipal forests which would be without question for investment purposes. This law, therefore, provides for the establishment of school endowment forests by any towns so voting. Any tract of forty acres or over, owned by a town, may, upon the approval of the state forester, be set aside as a school endowment forest. The town may secure the trees to plant this land from the state nursery. Table V, giving the probable profits from plantations shows that plantations costing $12 an acre to form should yield a profit in 50 years of from $136 to $314 an acre. Hence a town which planted 40 acres of the poorest forest soil might have a net profit over and above 4 percent on the money invested at the end of 50 years of over $5,000 which reinvested at 5 percent would yield an annual income for the schools of $250. If the town preferred it might invest the whole $5,000 in school buildings. Suppose another town with 100 acres of medium land should plant 10 acres every 5 years. In 50 years, when the last of the area had been planted for four years, the first one would be ready to cut and the town might have a periodic income from that time



Plantation of Scotch Pine three years after planting. Land of the University of Vermont, Burlington.



Usual method of planting with Mattocks. (The sugar snow is no great disadvantage).

of about $2,000 every 5 years. This, it must be remembered, is the profit over 4 percent compound interest on the whole investment. If a third town gradually acquired 500 acres for this purpose, and annually planted 10 acres for a period of 50 years, the future annual net income might easily be $2,000 if the soil was of medium quality, or $3,000 if it was of first class quality.

There are several classes of land which Vermont towns may be expected to use as school endowment forests.

(a) Many towns own lands surrounding their reservoirs which can not be cultivated for any length of time because they cannot be fertilized. A forest cover prevents evaporation, retards the melting of snow, and in other ways protects the water supply. Such land would be doubly useful if planted with forests, because they would in time yield a revenue.

(b) Occasionally tracts of cut-over forest lands are sold for taxes. Such lands are usually of third quality soil and are, therefore, less profitable for planting than more expensive lands. However, the town can afford to bid these in at a price which the private individual might not care to pay because of the indirect value to the town from having the land productive and the water supply protected. It should be remembered that a tax title is not very good and it is well to pay a little more for a quit claim deed.

(c) In many towns there are public spirited men who would be glad to endow the schools of their town either by outright gift of land or by willing such land to the town. It might be well for the town clerk in each town to canvass his town for such donations.

(d) In many towns there are abandoned farms which are practically non-productive, on which the taxes amount to very little. In many cases it would be good policy for the towns to buy some of these abandoned lands and reforest them. They would in that way become productive and would in time furnish more remunerative work to the people of the town than they ever will in their present condition, and because of this fact the population of the town can be increased.

The question of establishing a school endowment forest should be brought up before every town. The new law reads as follows:

NO. 24 OF THE ACTS OF 1912

AN ACT TO PROVIDE FOR SCHOOL ENDOWMENT FORESTS

It is hereby enacted by the General Assembly of the State of Vermont.

Section 1. Towns and cities may at any legal meeting grant and vote such sums of money as they may deem best for the purchase, management and improvement of lands for the purpose of growing wood and timber thereon.

Section 2. Any town or city having in its possession, either through donation, purchase or forfeiture for taxes, a tract of land of not less than forty acres, may have the same examined without cost by the state forester for the purpose of determining whether the same is suitable for a school endowment forest. If, upon examination, the state forester decides that it is suitable for such purposes, it shall be designated as a school endowment forest, and the state forester shall give advice as to what trees shall be planted thereon and as to the subsequent management thereof.

Sec. 3. The state forester is authorized to distribute annually 150,000 trees from the state nursery among towns for the planting of school endowment forests, said trees to be sold at the same prices as those to private individuals.

Sec. 4. School endowment forests shall be managed under the direction of the state forester, and only such trees may be cut as he may, from time to time, designate. The protection of the forest shall be under the town forest fire warden, who shall be compensated for his services by the town at the same rate as is paid for fighting forest fires, upon the approval of his account by the state forester.

Sec. 5. All money received for the sale of lumber, wood or other produce from a school endowment forest, shall be deposited with the treasurer of the town owning the same, who shall render an annual report of all money so received to the state treasurer.

Approved April 1, 1915.

APPENDIX

HEIGHT GROWTH

The best data available as to the height growth of the species recommended is included in the following table:

TABLE VIII

Height growth in feet of species recommended for planting.

Age in years	White pine[1]			Norway pine[2]	Balsam fir	White ash
	Upland pasture	Sandy soil	Wet swamp	Average[2]	Average[3]	Average[4]
10	9	5	4	12	..	..
20	24	23	16	35	14	39
30	40	36	28	58	25	53
40	53	44	39	70	36	63
50	64	51	48	77	45	71
60	73	57	54	82	52	77
70	80	61	60	85	59	82
80	84	65	65	88	64	86
90	89	..	70	90	68	90
100	91	..	..	91	71	93

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[1] Mass. State Forester, "Forest Mensuration of White Pine."
[2] U. S. For. Serv. Bul. 139 (1914), Bayfield Co. Wis.
[3] U. S. For. Serv. Bul. 55 (456 trees in Maine).
[4] Vt. Sta. Bul. 176 (1914). Vt. For. Serv. Pub. 13.

DIAMETER GROWTH

Diameter in inches of trees of different ages

TABLE IX

Age in years	White pine[1]		Norway pine[2]	Balsam fir[3]	White ash[4]
	Quality I	Quality III	Average	Average	Average
10	1.7	1.0	.6	...	...
20	4.0	2.3	2.8	1.2	4.1
30	6.4	3.9	5.7	2.7	6.1
40	8.6	5.5	8.0	4.1	7.9
50	10.8	7.0	9.9	5.5	9.5
60	12.8	8.6	11.7	6.7	10.8
70	14.7	10.1	13.2	7.9	11.8
80	16.5	11.7	14.6	8.9	12.6
90	18.2	13.2	15.9	9.9	13.8
100	19.8	14.5	16.9	10.7	13.8

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[1] Report of Forest Commissioner of N. H., 1905-06.
[2] U. S. Dept. Agr. Bul. 139 (1914).
[3] U. S. Dept. Agr. Bul. 55 (1914).
[4] Vt. Sta. Bul. 176 (1914). Vt. For. Serv. Pub. 13.

A FORESTRY ARITHMETIC

FOR VERMONT SCHOOLS

By A. F. HAWES
State Forester

VERMONT FORESTRY PUBLICATION NO. 14

APRIL 1914
THE VERMONT PRINTING COMPANY
BRATTLEBORO

TO THE TEACHER

Forestry, as a branch of agriculture, has made remarkable progress in the past few years. People are beginning to see that the old way of considering the forest as a mine to be exploited is wrong, and that the forest should be considered as a growing crop to be protected, improved, harvested and grown again just like corn or grass, except for the length of time necessary to grow a crop. The older people have adopted this new attitude even more than could have been expected of them, considering the length of time required to grow timber. But it is with the future generation that the practice of forestry must be expected. It is, therefore, necessary to instruct and interest the young in the principles of forestry. Several books have been written with a view to giving forestry instruction that can be understood by children. Much can be accomplished indirectly through suggestion. Teachers have long recognized the value of using text books in such subjects as arithmetic and grammar, based upon the facts of country life. The purpose of this bulletin is to give the Vermont teacher some examples in arithmetic which can be used to supplement the regular text book used, and which will suggest to the scholar many of the important forestry ideas which it is desirable for our young to have.

At the end of the bulletin are reprinted some forestry experiments originally prepared by the writer for a bulletin published by the State Commissioner of Education.

PART I. FORESTRY ARITHMETIC

ADDITION.

(1)

The following loads of spruce logs were hauled eight miles by one two-horse team and sled in the winter of 1911-12, near Stowe, Vermont. How many logs and how many board feet were hauled?

Number of logs	*Contents of logs in board feet*
9	1128
12	876
15	1150
17	1298
18	1114
12	1104
11	1278
13	1300
16	1370
12	950
15	1150
16	1264
19	1370
17	1664
17	1340
18	1668

(2)

What was the total amount of lumber cut in Vermont in 1906, when the following amounts of the different kinds were cut?

White pine, twenty-four million, nine hundred and forty-four thousand feet; hemlock, fifty-six million, and forty-two thousand feet; spruce, one hundred and thirty-six million, eight hundred and sixty-seven thousand feet; maple, thirty-four million, eight hundred and fifty-nine thousand feet; basswood, nine million, four hundred and eighty-two thousand feet; birch, twenty-nine million, five hundred and seventy-seven thousand feet; beech, fourteen million, nine hundred and seventy-six thousand feet; ash, five million, one hundred and eighty-four thousand feet; others, seventeen million, four hundred and ninety-one thousand feet.

(3)

In the spring of 1912, the following lots of seedlings were sold from the State Nursery to people in the various counties of Vermont, at cost price. How many were sold in the State?

Addison	57,000
Bennington	11,200
Caledonia	29,000
Chittenden	5,200
Essex	1,000
Franklin	49,200
Lamoille	5,000
Orange	18,500
Orleans	11,000
Rutland	81,200
Washington	68,500
Windham	39,000
Windsor	154,600

(4)

Here is a list of the state forests of Vermont with their areas. In these forests the best methods of forestry are demonstrated. Which one is nearest your home? What is the total area of the state forests?

Chas. Downer Forest, Sharon	800 acres
L. R. Jones Forest, Plainfield	600 acres
M. J. Hapgood Forest, Peru	100 acres
J. Battell Forest, Duxbury & Huntington	1,200 acres
Lyndon Forest	75 acres
Geo. Aitkin Forest, Mendon	850 acres
West River Forest, Townshend	700 acres
Arlington Forest	225 acres
West Rutland Forest	350 acres

(5)

The State Nursery in Burlington, Vermont, contained on July 1, 1911, the following trees. What was the total?

White pine 3 year transplants	460,000
White pine 2 year seedlings	540,000
Scotch pine 5 year transplants	1,000
Scotch pine 4 year transplants	8,000
Scotch pine 3 year transplants	100,000
Scotch pine 2 year seedlings	28,000
Norway spruce 3 year transplants	15,000
Norway spruce 2 year seedlings	35,000
White cedar 4 year transplants	2,000
Austrian pine 3 year transplants	4,000

SUBTRACTION.

(6)

If a man owns 1,000 acres of land that is worth $2,000 and lumber on it worth $10,500 and sells off lumber to the value of $7,650, what is the value of the remaining property?

(7)

If a farmer owns 200 acres, and his cultivated fields amount to 62 acres; his pastures to 44 acres; and the rest of the land is woodland, how much woodland has he?

(8)

A man in Enosburg, Vermont, plans to plant 344 acres with forest trees. He has already planted 38 acres in 1910; 40 acres in 1911; 44 acres in 1912; and 45 acres in 1913. How much more land has he to plant?

(9)

A white pine tree, which grew on rich lowland, contained, when it was 70 years old, 68 cu. ft. and when it was 80 years old 84 cu. ft. Another tree, which grew on a sandy soil, contained, when it was 70 years old, 31 cu. ft and when it was 80 years old 39 cu. ft. Which tree grew the more during the ten years, and how much more did it grow?

MULTIPLICATION.

(10)

A farmer has decided to plant 17 acres of worthless land to pine trees. On consulting a forestry bulletin he finds that he will need 1200 trees per acre, and that he can purchase three-year-old white pines for $5 a thousand. How many trees must he buy, and what will they cost him?

(11)

Mr. Johnson has an acre of pine woods with 70 trees on it, and the average tree contains 215 board feet. Mr. Robinson has an acre of similar growth with 95 trees, and an average tree of 195 board feet. If they should exchange acres, which would get the best of the bargain?

(12)

There is an able man in Amsden, Vermont, who can chop five cords of wood a day under favorable circumstances. His neighbor can only chop two cords a day. It would probably not be possible for this good chopper to do as well right along, but if he could, how much more would he have chopped Saturday night than the other fellow, if they both began Monday morning?

(13)

If the spruce seedlings in a forest grow an average of three inches a year in height, and those in the open, which have plenty of light and moisture, grow four times as much, how much do those in the open grow?

(14)

If the squirrels in a woodlot collect and store three bushels of red oak acorns, and there are 4650 acorns in a bushel, how many will they have stored?

DIVISION.

(15)

Mr. Hills is anxious to plant his unused piece of land to Norway spruce trees five feet apart each way. He measured the piece and found that it was rectangular, 870 feet long and 620 feet wide. How many trees will he need to plant the piece in the manner desired, and what will they cost at $6 per thousand?

(16)

The man in charge of the State Nursery found that he could pack 3500 seedlings in a box of a certain size. How many boxes will he need to pack 653,000 in?

(17)

What was the average number of logs, and the average amount in board feet per load, described in Question 1?

(18)

Seed collectors get about 28,000 white pine seed out of one bushel of cones. How many bushels must they collect to produce 1,500,000 seed?

(19)

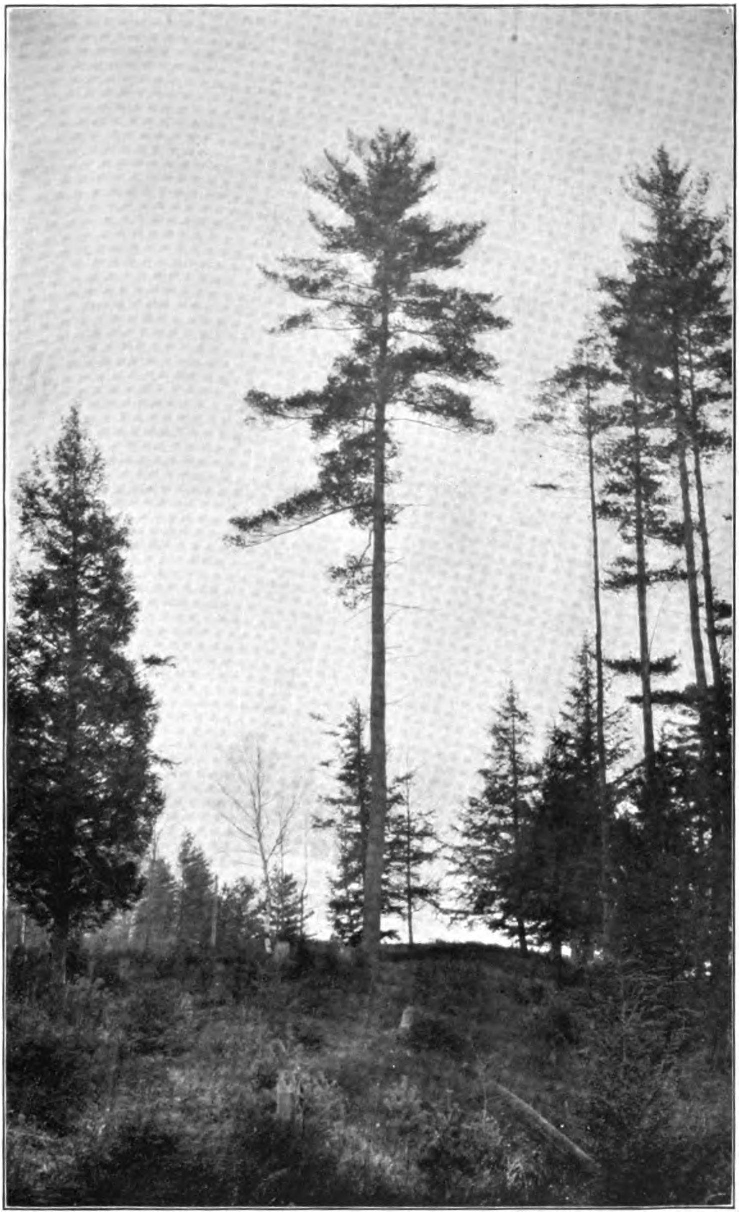
In 1911 it cost several towns in Vermont $627.57 to put out 39 forest fires. What was the average cost of putting these out? The total area burned by the same fires was 2150 acres. What was the average area burned?

(20)

The Government of Saxony receives an income of $6.02 an acre from its state forests, the combined area of which is 430,000 acres. Another German state, Wurtemberg, has a total income from its state forests of $3,607,860. The area of the Wurtemberg forests is 471,000 acres. Which state has the larger income from its forests, and which makes the more per acre?

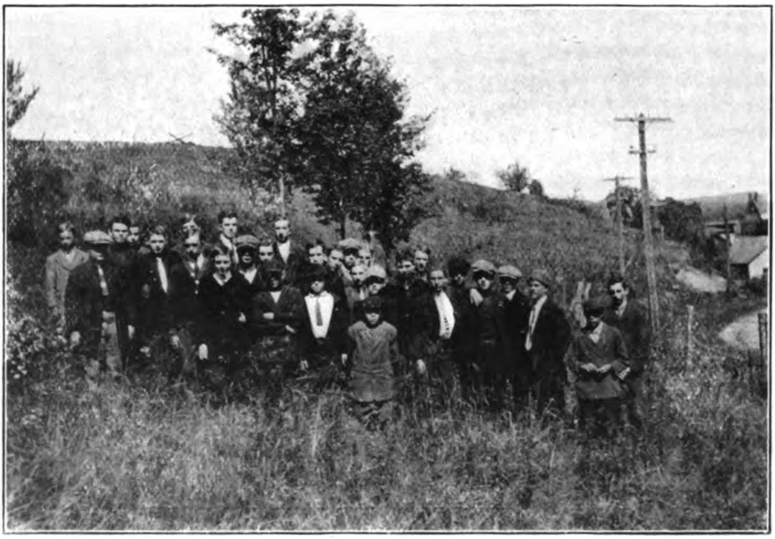
(21)

If a hemlock tree 222 years old is worth standing $2.09, what has been its average growth in value each year? In the same forest there is a pine tree 80 years old which is worth $2.22 standing. How much money has this tree made each year? Which kind would you prefer to have working for you?



THE WHITE PINE IS OUR MOST VALUABLE TREE.

THIS YOUNG FOREST OF SCOTCH PINE
WAS PLANTED SIX YEARS AGO.



THE BOYS OF THE STOWE SCHOOL
ON A FORESTRY EXPEDITION.

FRACTIONS.

(22)

The total area of Vermont is 5,846,000 acres. One-third of it is used for farm crops. The rest of it is waste and woodland. What is the area of waste and woodland?

(23)

Meehan & Sons quote white spruce seed @ \$2.40 per lb.; Norway spruce @ \$.90; red spruce @ \$2.25; Norway pine @ \$5.75; white pine @ \$1.50; and Scotch pine @ \$1.25. Mr. Hall bought 2¼ lbs. of white spruce seed; 6½ lbs. of Norway spruce; 3⅔ lbs. of red spruce; ¾ lb. of Norway pine; 7⅜ lbs. white pine, 5⅓ lbs. of Scotch pine. What was the amount of his bill?

(24)

Mr. Chandler owns 3,000 acres of pine forest, and has found that it requires 50 years for this forest to grow. He intends to cut as much of his forest each year as possible, and have enough left so that he and his son can continue cutting right along. What part of the area, and how many acres can he cut over each year?

(25)

Mr. Smith built a telephone to the summit of Gore Mountain for a fire lookout station. He estimated that if the distance was three miles it would cost \$120. It was one-fourth greater than he estimated. What was the distance and expense?

(26)

On a certain woodlot the standing timber was estimated at 165,000 board feet. A lumberman purchased three-quarters of it and contracted with woodchoppers to cut one-half of what he had purchased. After the choppers had finished their contract a forest fire destroyed two-thirds of the lumber they had cut. How much was burned?

(27)

Mr. Flint bought a woodlot for \$685 and sold it two years later at a profit of one-fifth of what he had paid for it. The purchaser held it a year, and was then obliged to sell it at a loss of one-fifth of what he had paid. How much did he get for it?

DECIMALS.*

(28)

The pine seedlings in the woods of the University of Vermont made the following average height growth:

1904	3.8 inches	1907	6.3 inches
1905	5.9 inches	1908	5. inches
1906	6.1 inches	1909	8.7 inches

What was the average height growth for the six years?

(29)

A careful measurement of a pine forest 40 years old showed that it contained 58.3 cords per acre. When it was 50 years old this same forest contained 70.2 cords. What was the average annual growth for the decade? At that rate how much would it contain when 60 years old?

(30)

It requires 3.9 hours of hand labor to remove 1 cubic yard of dirt 1,000 feet; while with animal labor it requires only .46 of an hour. How much more dirt can be moved this distance in a ten-hour day by animal than by hand labor?

(31)

The freight rates on a car of lumber between different points are given below. The smallest amount charged for a car is 34,000 lbs. What is the total cost on such a carload in each case?

	Rate on 100 lbs. of freight
Cambridge Junction to Burlington	5.5 cents
White River to Brattleboro	6.7 cents
Brattleboro to Boston	8.6 cents
Rutland to New York	11.5 cents
Ludlow to Rutland	4.5 cents

(32)

A farmer grows 84.32 cords of hardwood on 3.6 acres in 40 years. How much did he grow on an acre? What was the average growth for a year on an acre?

---

*Decimals seem to be less understood by adults than fractions. Children should receive special training in the use of decimals.

PERCENTAGE.

(33)

There are about 28,000 white pine seed in a pound, and experiments have shown that about 70% are good and begin to grow. If 40% of these little seedlings die before they are two years old, how many seedlings could be raised from three pounds of seed?

(34)

On a rocky hillside in southern Vermont, where there are 345 trees to the acre, it is estimated that 69% are hemlock; 15% maple; 5% beech; 3% pine; 7% birch; 1% ash. In order to increase the proportion of the better trees 60% of the hemlock and 30% of the beech were cut. How many trees of each species were left?

(35)

On a road over the Green Mountains, it was found that in a distance of four miles there was a rise of 2,040 feet, while in the steepest place there was a rise of 175 feet in 480 feet. What is the average and greatest per cent of grade? By per cent of grade is meant the number of feet of rise in 100 feet of horizontal distance.

(36)

If a pine forest 50 years old is worth $470 an acre, and the owner has paid altogether 66% of its value in taxes, how much profit does he get from it? What is the average profit per year?

(37)

The areas of the state forests of the other states in United States are given below. (a) What is the total area contained in state forests? (b) What percentage do the Vermont state forests form of the total area of such forests in the country? (See Question 4 for the area of the Vermont state forests.)

California......................	3,800 acres
Connecticut.....................	2,120 acres

Indiana	2,000 acres
Maryland	1,950 acres
Massachusetts	15,000 acres
Michigan	231,350 acres
Minnesota	43,000 acres
New Hampshire	6,900 acres
New Jersey	13,720 acres
New York	1,644,088 acres
Pennsylvania	983,529 acres
South Dakota	75,000 acres
Wisconsin	400,000 acres

(38)

Mr. Ross has planted 100 acres of cheap land with white pine, and has entered this land under No. 40 of the Acts of 1912. He expects to sell in 30 years 12,500 feet of lumber per acre, over the whole area; and to receive $8 per thousand board feet for it "on the stump." The law provides that he must pay a tax of 10% of the total stumpage value. What would this tax amount to? The land is valued at $3 an acre throughout the 30 years and the tax rate in his town is 2%. How much tax does he pay on the land during this period that the lumber is growing? What then is the total tax that he has paid, disregarding compound interest?

(39)

The State law reads that when in any one year the bill for fighting forest fire amounts to over 5% of the grand list of that town, the State pays the sum over 5% of the list. Last year the town of Stratton paid $291.40 for fighting fire and the grand list of this town was $1,776.30. Did the State have to pay anything, and, if so, how much?

(40)

Mr. Clarke has a saw mill valued at $12,500. He insures the mill at 75% of the valuation, the insurance rate being 10% a year. What premium does he pay the insurance company each year?

SIMPLE INTEREST.

(41)

Mr. Green has a forest of 1,000 acres, the value of which is as follows: Land, $2,000; timber, $10,500. The tax on this property is 2% on a valuation of 50% of its real value. How much tax does he pay?

(42)

Mr. Foss receives annually an income of $500 from his forest, and estimates that this is 7% interest on the value of the forest. What is the total value of the forest, and how many acres does he own if the land and timber is worth $45 an acre?

COMPOUND INTEREST.

(43)

The State recently purchased 75 acres of sandland in Lyndon at $2 per acre, and planted it with pine trees for $9.50 per acre. What is the total amount invested, and what will this amount to in 10 years at 4% compound interest?

(44)

It is estimated that a certain tract of timber will be worth $2,000 in 10 years. Considering interest at 4%, what is it worth at present? After a forest fire it is estimated that this tract will be worth only $650 in 10 years. What is it worth immediately after the fire? How much damage has the fire done?

(45)

Mr. Jones has a 100 acre lot of white pine which will average 20,000 board feet to the acre. The tax listers value this pine at its true stumpage value of $8.00 per thousand feet. If the tax rate is 2% what will Mr. Jones' tax amount to in four years at 4% compound interest?

DEFINITIONS. I.

One acre contains 43,560 square feet.

One acre contains 160 square rods.

One square acre is 208.7 feet on a side.

One circular acre has a radius of 118 feet.

One circular half-acre has a radius of 83 feet.

One circular quarter-acre has a radius of 59 feet.

One mile is 5,280 feet.

One mile is 320 rods.

$\pi = 3.1416$. This is the constant ratio of the circumference to the diameter of a circle.

The area of a circle is equal to πR^2 when R is the radius.

The circumference of a circle is equal to $2\pi R$.

The volume of a cylinder is equal to the area of the cross section multiplied by the height, or $A \times H$.

The volume of a cone is equal to one-third of the product of the basal area multiplied by the height, or $\frac{A \times H}{3}$

The volume of a log is equal to one-half the area at the base plus the area at the top, multiplied by the length, or $\frac{A+a}{2} \times L$

(46)

If pine trees are planted six feet apart each way, how many would one need to plant six acres?

(47)

If one had 500 trees and planted them five by six feet, how many square rods would they cover? What fraction of an acre?

(48)

If a man finds that his average pace is 2.6 feet, how many paces would he take in going about a square area of four acres?

(49)

How many acres would there be in a circle with a diameter of one mile? How long would it take to walk around such a circle at the rate of 3½ miles an hour?

(50)

If one has a bicycle with a wheel 28 inches in diameter, and the wheel turns around 1,840 times in riding from school home, how long would it take to walk this distance at the rate of four miles an hour?

(51)

How much would a tank contain which was 3 feet in diameter and 10 feet high? What would be the diameter of a cone of the same height and volume?

(52)

Mr. Smith has two logs. One is 12 feet long, with diameters of 24 and 20 inches at the two ends. The other is 16 feet long, with diameters of 20 and 16 inches. Which contains the more wood, and how much more?

(53)

A spruce tree is sawed into four 12-foot logs. The diameters outside the bark at the base of each of these and the top of the smallest are respectively, as follows: 21, 18, 16, 13, and 10 inches. The same diameters inside the bark are: 20, 17, 15, 12.4, and 9.5 inches. What is the volume of the wood and the bark of the tree, not including branches?

(54)

It has been found that a balsam tree contains .457 and a hemlock .547 of the volume of a cylinder of the same base and altitude. What would be the contents of a tree of each of these kinds 12 inches in diameter and 60 feet high?

(55)

A pine tree grown in a forest is 24 inches in diameter at the base and 70 feet high. At a height of 50 feet it is 10 inches in diameter. Another pine grown openly in a pasture has the same diameter at the base and the same height, but at 50 feet it is only 3 inches in diameter. How much more wood is there in the first 50 feet of the forest-grown tree? Considering the tops as cones, what are the total volumes of the two trees?

DEFINITIONS. II.

A cord is a stack of wood containing 128 cubic feet. The usual dimensions are: Length of sticks, 4 feet; height of pile, 4 feet; length of pile, 8 feet. Any other combination which makes 128 cubic feet makes a cord.

About 70% of the contents of a cord are wood, and 30% air, depending upon the size and shape of the sticks.

A "cord foot" is one-eighth of a cord, or a pile of four-foot wood, four feet high, one foot long.

A "running cord" or "run" of cord wood is one-third of a cord, or a pile of wood cut 16 inches long for stove purposes, piled four feet high and eight feet long.

A board foot is a board one foot square and one inch thick.

The unit of measure of lumber in this country is 1,000 board feet.

One thousand board feet is equivalent to about two cords of wood. This, however, depends upon the size of the logs, as small stick will make cord wood, but not lumber.

A "log rule" or "log scale" gives an estimate of the number of board feet that can be sawed from a log of any dimensions.

There are a great many different "log rules" in use in this country, which give widely different estimates for logs of the same dimensions.

According to the Vermont law the Vermont Rule is the legal scale for use in the purchase or sale of lumber in Vermont.

According to this rule, the contents of a 12-foot log in board feet are equivalent to the product of the diameter at the top inside the bark, multiplied by half this diameter. For logs of other lengths, the contents are proportional. Expressed by formula where

Bd. ft.=board feet,
D =diameter at the top in inches
L =length in feet

$$\text{Bd. ft.} = D \times \frac{D}{2} \times \frac{L}{12}$$

The Vermont Rule gives fair results for logs of average diameters, but underestimates the contents of large logs, and somewhat overestimates the contents of very small logs.

(56)

Mr. Hills bought for his fireplace, wood cut two feet long, and paid at the rate of $10 a cord. His pile was 16 feet long and three feet high. How much did he pay?

(57)

A farmer cut a large birch tree into four sound logs of the dimensions given in Question 53. He was offered $3 a cord for the wood split and piled, and $8 per thousand board feet for them for lumber. Which price is the better, and how much better if it costs 70c. a cord to split and pile? Use the Vermont Rule to obtain the number of board feet.

(58)

How many board feet are there in a plank 14 feet long, 2 inches thick and 10 inches wide?

(59)

What would the bill be for 20 spruce beams 6″×6″ and 20 feet long, at $25 per thousand board feet?

(60)

How many runs would it be possible to get out of a pile of 4-foot wood, 40 feet long and 6 feet high.

(61)

A lumber company recently purchased a tract of 1,200 acres estimated to yield 6,000 board feet of spruce and fir per acre. What is the total stand in lumber? In cords of pulp?

(62)

A lumber company in southern Vermont has just built a saw mill in which they expect to saw 70,000 board feet of lumber each day, counting 300 working days for the year. They will finish their cut in about 10 years.

(a) How much lumber will this company have taken during the 10 years, and what would the value be at an average price of $18 a thousand for the sawed lumber?

(b) If this land is worth $1 an acre and the lumber $4 per thousand board feet on the stump, how much was their property worth when they began operations? And what will it be worth when they have finished, if the total area is 90,000 acres?

(63)

The following shipments of lumber were made from Stowe, Vermont, to Boston, Mass.:

	Amount shipped	*Freight cost*
Car 1..........	18,329	$55.10
Car 2..........	16,497	63.46
Car 3..........	18,486	49.30
Car 4..........	18,753	55.10
Car 5..........	17,660	49.30
Car 6..........	20,560	53.80
Car 7..........	18,095	52.93
Car 8..........	18,324	53.36

What is the average amount shipped in a car? And what is the average cost per thousand feet to ship lumber to Boston from this point?

(64)

If the Stoddard Rule gives 59 board feet as the contents for a log 12 feet long and 12 inches in diameter, and the Vermont Rule gives 72 board feet as the contents of the same log, how many such logs would a farmer have to sell to make 10,000 board feet by the Stoddard Rule, and by the Vermont Rule?

(65)

By the mechanical process one cord of wood gives 1,650 pounds of paper pulp. A paper company uses 250 tons of such pulp each day.

(a) How many cords of wood are used in making this pulp, and how many acres are cut over each day if there is an average of 10 cords of wood to the acre?

(b) How many acres would they cut over in a year if the mill runs 300 days during the year?

DEFINITIONS. III.

Foresters use volume tables to aid them in estimating the contents of standing timber.

A volume table gives the average number of board feet, or the average fraction of a cord, of standing trees of different dimensions.

A volume table, to be correct, must be based upon the careful measurement of a great many felled trees, and should only be applied in the section of the country where it was made, and for the kind of trees for which made.

To apply a volume table, one measures the diameters of the trees in a forest, usually with calipers. The diameters are always measured at breast height, or 4½ feet from the ground. If more convenient, the circumferences may be measured with a tape and the diameters calculated.

A volume table is for standing trees what a log rule is for felled logs. Neither is accurate for individual cases because logs, and especially trees, vary in shape. The greater the number of trees measured, the more accurate is the application of a volume table.

Below is a volume table for beech, giving the average volumes in board feet or fractions of a cord of trees varying in diameter from 10 to 24 inches. To illustrate the use of this table, suppose that one has measured 10 sound beech trees 20 inches in diameter. From this table he would find that they would yield 10×296, or 2,960 board feet. If they were unsound and not fit for lumber, they would make 4.8 cords of wood.

BEECH VOLUME TABLE.

Made by Hosmer by Use of a Curve by Bangor Rule.

Diameter Breast High Inches.	*Average in Board Feet.*	*Average Contents in Fraction of Cord.*
10	57	.16
11	76	.18
12	95	.21
13	114	.25
14	134	.29
15	156	.33
16	180	.36
17	207	.39
18	235	.42
19	264	.45
20	296	.48
21	328	.61
22	360	.54
23	393	.51
24	425	.60

EXAMPLES.

(66)

A farmer has a hardwood forest of four acres, in which he has measured the beech trees as follows: 10 inches, 20 trees; 11 inches, 14 trees; 12 inches, 17 trees; 13 inches, 10 trees; 14 inches, 5 trees; 15 inches, 8 trees; 16 inches, 4 trees; 17 inches, 2 trees; 18 inches, 3 trees; 19 inches, 1 tree; 20 inches, 3 trees. How many cords of beech wood per acre does his woodlot average?

(67)

He has agreed to sell all the trees 14 inches and over for $4 per thousand board feet, standing. Provided they are all sound, how much would he receive?

(68)

When the owner came to cut these trees he found that the following trees had been so injured by a forest fire several years ago, that they would only make cord wood, which he had to sell for 75c. a cord standing. Trees so damaged: 14 inches, 2 trees; 15 inches, 3 trees; 16 inches, 2 trees; 17 inches, 1 tree; 18 inches, 2 trees; 19 inches, 1 tree; 20 inches, 2 trees. How much damage did this old fire do to these trees?

(69)

A builder arranged with a farmer to buy from him enough standing beech trees to make 4,500 board feet of lumber, and to cut only the largest trees. The trees standing were as follows: 15 inches, 7 trees; 16 inches, 5 trees; 17 inches, 3 trees; 18 inches, 6 trees; 19 inches, 4 trees; 20 inches, 2 trees; 21 inches, 3 trees; 22 inches, 1 tree; 23 inches, 2 trees. Which trees were cut?

(70)

The builder also agreed to buy the remaining trees at the end of five years, paying $4 per thousand board feet on their present volume, and 3% compound interest for their growth. How much will he pay then?

(71)

A lumberman bought all the standing beech on Mr. Brown's farm for $100. The trees measured as follows:

Diameter inches.	*Number of trees.*	*Diameter inches.*	*Number of trees.*
10	30	17	15
11	27	18	12
12	20	19	14
13	24	20	10
14	16	21	11
15	21	22	9
16	22	23	11
		24	6

By the contract, he has 10 years to cut them off. He cut at once 50% of all the lumber, including all trees which showed signs of decay. The remaining timber he estimates is growing at the rate of 5% compound interest, and he will not cut it until obliged to. If it is worth $4 per thousand feet now, and $5 at the end of 10 years, how much will he realize for the portion he leaves standing? He invests the money from the first cut at 4% for the remaining 9 years. How much is the total value of the lumber to him at the end of the period, not considering taxes?

Questions 72 and 73 illustrate what is known as the economic "Law of Diminishing Returns." You will get some idea of what this law is by doing these examples.

(72)

If a man and team hauls 500 board feet of lumber to a load, and charges $4.00 per day, how much does it cost to haul 1,000 board feet

(a) If he makes one trip a day?
(b) If he makes two trips a day?
How much per 1,000 ft. is saved by the second trip?
(c) If he makes three trips a day?
How much per 1,000 ft. is saved by the third trip?
(d) If he makes four trips a day?
How much per 1,000 ft. is saved by the fourth trip?

(73)

Crews for planting forest trees are organized differently, depending on the number of men available. What size crew will plant the cheapest where 2 men can plant 500 trees; 3 men, 1,000 trees; 4 men, 3,000 trees; 5 men, 3,500 trees; 6 men, 3,600 trees; 7 men, 4,000 trees per day?

PART II. EXPERIMENTS IN FORESTRY.*

Forestry is a subject which cannot satisfactorily be studied out of a book or in the laboratory. The teacher should take the students for field excursions or assign definite periods for outdoor study. Many questions will arise which are not mentioned in these few exercises, whose only purpose has been to start the students thinking along forestry lines. It is not enough in our nature studies to create a love of the forest. That is inborn with every child, but when he becomes a land owner he is forced by the struggle for existence to treat his forest as an income-producer. It is, therefore, important for children to understand the principles underlying forest growth, so that they will consider the forest as a crop to be harvested, and grown again, and not as a mine or a quarry to be exploited and abandoned.

Exercises 1 and 4 will necessarily have to be studied in the spring; 2 and 3 in the fall; while the remainder may be taken at any time most convenient for getting into the woods.

EXERCISE 1.

OBJECT: To learn the tree flowers.

DIRECTIONS: Watch the trees of your region in the spring to see if they have flowers of any kind. Make a list of the trees in the order in which their flowers appear. Describe or draw the different flowers. Do you see any resemblance between the flowers of different trees, as the birch and poplar? If so, what trees have similar flowers? If correctly noted, this will show which trees are related. Look particularly for the small flowers of the pine, spruce, or tamarack.

REFERENCE: Vt. Exp. Sta. Bulletin 73, "The Trees of Vermont.

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*For a more complete set of forestry experiments see **Farmers** Bulletin 468 by E. R. Jackson, U. S. Dept. of Agr.

EXERCISE 2.

Object: To learn the tree seeds.

Materials: Collections of different kinds of tree seeds, pine cones, etc.

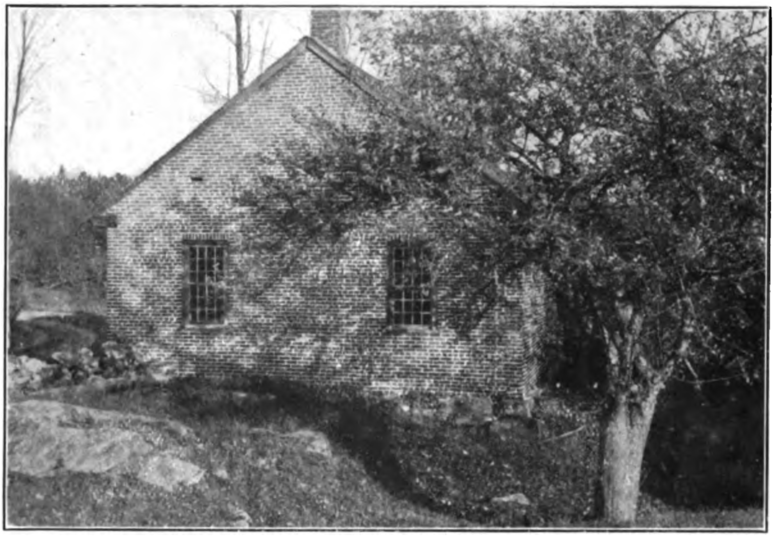
Directions: Some trees ripen their seed in the spring, but most of them in the fall; so the latter (September or October) is the best time to study this exercise. What trees have nuts? Under pine and spruce trees you may find cones. These are not the seed, but the seed grow in the cones. If you do not find any seed in the cones you have collected, climb the tree and pick some cones that have not opened. Dry these out in the sunlight of the window and note the seeds. Where are the seeds in the cone and how many of them? Why were there no seed in the dry cones on the ground? How would you go to work to collect a lot of seed of spruce, birch, ash and oak?

Reference: Vt. Exp. Sta. Bulletin 73, "The Trees of Vermont."

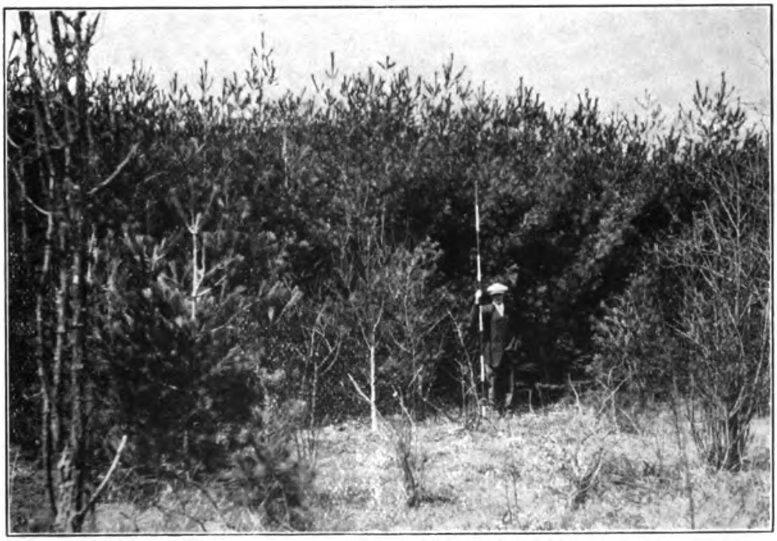
EXERCISE 3.

Object: To study tree seed distribution.

Directions: In the fall go into a pasture where there are a few scattered butternut or beech or hickory or other nut trees. Notice how far away from these trees you find the nuts. If it is on a hillside, how far down the hill do the nuts roll? You may find a pile of nuts hidden somewhere. If so, who collected them? Go into the woods when the wind is blowing in the fall and try to find some seeds being carried by the wind. You will notice that some of them twirl around in the air and seem to sail farther than others. What makes this? What kind sail farthest? Out in the pasture on the edge of the woods, how far from the woods can you find the seed of maple and ash? On a pleasant day after the first snow in the fall, go into the woods and try to find tree seeds on the snow. What do you find the most of? Is it because there are more large trees of that kind, or because the seed is more plentiful and can be blown long distances? If this happens every year you would expect a great many little trees of this kind.



THIS GOOD SCHOOLHOUSE IN SOUTHERN VERMONT
IS ABANDONED BECAUSE OF LACK OF
PROFITABLE INDUSTRY.



A WHITE PINE PLANTATION
FIFTEEN YEARS OLD.

A VIRGIN FOREST IN
PERU, VERMONT.

SIFTING SAND OVER THE SEED BEDS
IN THE STATE NURSERY.

EXERCISE 4.

OBJECT: To study tree seed germination.

DIRECTIONS: This exercise should be studied in the spring. If there is a cider mill near you, visit the pile of pulp in May or June and see if you find anything growing on it. Get down on your hands and knees under the old maple tree by the roadside and try to find some little maples. Do you find many? What becomes of them? Why don't they grow up? Go into the sugar orchard and see if there are little maples there that are growing up into good trees to take the place of the old ones. If not, why not? If you have a pond or lake or river near you, go along the shore and see if you find any forest seedlings coming up just above the water line. What kind are they and why should they grow here? Find an old, decayed log or big stump in the woods. Is there anything growing on it? Sometimes you will find a straight row of big trees that started in that way.

EXERCISE 5.

OBJECT: To show the height growth of trees.

MATERIALS: Rule, paper and pencil.

DIRECTIONS: Go where there are some young spruce or pines growing. Select some that are not too tall. Note that the limbs grow in whorls at different heights. At the top of the tree will be found a cluster of buds. What relation have these buds to the whorl of limbs? How can one determine the age by the whorls? Note the age and height of 10 trees. With the ruler measure the last year's growth; that of 1 year ago; 2 years, ago, etc. Which year did the tree grow the most? Find this out for several trees. Was it always the same year or different years? What was the greatest growth made in a single year?

EXERCISE 6.

OBJECT: To show the diameter growth of trees.

MATERIALS: Ruler, paper and pencil.

DIRECTIONS: Go to some woodlot which has been recently cut and where the stumps were sawed off so that the rings show plainly. Note which kind of trees have rings that are easiest to count. Count the rings on 10 trees of one kind but of different diameters, making record of the diameters and ages. Are the oldest trees also the biggest in diameter? Is the rate of growth uniform throughout the age of the tree? If not, can you think of any reasons for a change? At what period in the life of each tree did it make the most growth? During the past 10 years do you find that any one year was particularly favorable to diameter growth? If so, does it correspond to the year that the trees made a good height growing, in Exercise 62?

EXERCISE 7.

OBJECT: To show basal area growth of trees.

MATERIALS: Ruler, paper and pencil.

DIRECTIONS: Go to the same place as last exercise or a similar cutting. Find the diameter of one tree at the age of 20, again at 30, 40 and 50. The diameter can be considered as twice the radius. Take all the readings on the same radius. Subtract the diameter at 20 years from that at 30 and divide by the diameter at 20 to get the percentage of growth. Do the same for the other ages. What was the area of the cross section at 20, 30, 40 and 50 years. Get this by the formula: $A=\pi R^2$. Obtain the percentage of increase of area as of diameter and compare the two. This gives an idea of how rapidly a tree grows.

EXERCISE 8.

OBJECT: To make observations at the saw mill.

MATERIALS: Ruler, paper and pencil.

DIRECTIONS: Visit a saw mill if you can get permission. Watch the man who handles the log and saws off the boards. He is the sawyer, and is paid more than the other men, because he has to know the best way to saw up a log. Notice that when a new log goes in, he first saws off slabs with the bark. In some mills the sawyer cuts these slabs off the four sides and makes a square log first; in others, he saws the boards off the round log. In the first case the boards will be square edged; in the second, they will have bark on the edges and are called round edged. Which way does your sawyer do? What kind of logs have the greatest waste in slabs? What other form of waste is there? Did you notice any part of the trees wasted in the woods? The sawyer usually marks a number on each board as he takes it from the saw—what does this mean?

EXERCISE 9.

OBJECT: To study the rotting of wood.

MATERIALS: Paper and pencil, ax or hatchet.

DIRECTIONS: Find a place where some trees have been recently cut; or secure permission and cut down one or two trees. Note the difference in color between the wood in the center of the tree and that near the outside. Which is the heart wood and which sap wood? And which is the drier? Which part do you think would last longer? Find, if possible, an old fence post or clothes reel that has been taken out of the ground. What part of it rotted the more, heart or sap, above or below the ground? What kind of wood are most of your fence posts? What kind is used for railroad ties? In the woods, find some old logs that have been on the ground a long time. Cut into them with your ax. Do you find any of these sound inside? If so, what kinds?

BEAUTIFYING THE SCHOOL GROUNDS.

The school grounds in the rural districts of Vermont are far from what they should be. It is one of the regrettable facts of our school system that the school children so generally dislike school, and, even in after years, do not look back with pleasure to their school days. This is undoubtedly due to many factors, but among them may be mentioned the general ugliness of the school and its surroundings. A very little outlay of time and money on the part of the teacher or the school directors would go far to overcome these conditions. A few trees and clumps of shrubbery well placed will relieve the monotony of the school yard. Such planting, carried on in celebration of Arbor Day with appropriate remarks, may be the means of interesting the children in the general subject of tree planting, either for decorative or forestry purposes. Trees so planted in exposed situations should be protected by stakes or wire screens.

Good specimens of many native trees can be secured from the woods nearby, but in order to encourage this work the State Forester will hereafter provide sets of seedlings for this purpose. Tree roots, especially those of evergreens, are very delicate and should never be exposed to the sun or wind for more than a minute. When trees are dug from the woods, care should be taken not to break the roots. These should be carefully covered with wet sacking or something similar. If the trees are so collected or purchased before the desired time of planting they may be kept safely for some time by "heeling in;" that is, placing their roots in a trench and covering with soil. This trench should preferably be dug in a shady place. Deciduous trees, which are trees that shed their leaves annually, should be transplanted early in the spring before the buds have swollen, or in the autumn after the leaves have fallen. Evergreen trees also should not be transplanted while they are growing, which is usually from about May 15th to September 1st.

The State Forester offers for any school in the State a school package for 50c. containing transplant trees from six to ten inches high of the following varieties:

5 White Pine
5 Red or Norway Pine
5 Scotch Pine
5 Norway Spruce
5 White Ash

For towns wishing trees for several schools the State Forester will send, upon the request of one of the town officers, a number of trees of each of the above species equivalent to five such packages, the price being $2.00. These will be shipped in one package.

Upon the request of a district superintendent, where several towns desire trees, the State Forester will send a proportional number of each of these species for twelve packages, the price being $4.00. These will be shipped in one package.

THE VERMONT FORESTRY DEPARTMENT.

The Forestry Department was established by a law passed in 1908.

The object of the Department is:

(1) To help the people to raise better and more profitable forests;

(2) To make the waste land of the State productive;

(3) To provide more winter work for the men in our mountain towns;

(4) To furnish more lumber for the manufacturers who use wood and lumber;

(5) To protect the water supply of our mountains and thus save the springs and brooks of the valleys;

(6) To keep Vermont a beautiful and healthful State, attractive to our own people and outsiders who may wish to come here;

(7) To harbor the fish, birds and game dependent upon forests.

The work of the Department is done in a number of ways:

(1) Bulletins and circulars on forestry subjects are issued, which are free to all.

(2) A great many letters asking about forestry are received and answered annually. Such letters should be addressed: State Forester, Burlington, Vermont.

(3) Many lectures and addresses are made before clubs, associations, etc.

(4) A summer forestry camp at Sharon is open to boys who want to learn about forestry. The only expense is the cost of board.

(5) An expert will examine any land in Vermont and advise the owner how to improve his forest. The only cost to the owner is that of traveling expenses to and from Burlington.

(6) The State Nursery sells young forest trees for planting poor land. Little pines, three years old, cost $5.00 a thousand. Nearly a million trees are sold annually.

(7) The State Forests, which are located in different parts of the State, are maintained so that people can visit them and learn what to do with their own lands.

(8) The fire wardens in the various towns are responsible for preventing forest fires. Every boy and girl should help in this work by being careful not to start fires.

COMPLIMENTS OF
C. H. OTIS

MARCH, 1916 BULLETIN 194

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

THE TREES OF VERMONT

by G. P. BURNS and C. H. OTIS

BURLINGTON:
FREE PRESS PRINTING CO.,
1916.

PROPERTY OF DIVISION OF
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☞ Copies of the reports and bulletins of the Station are sent free of charge to any address upon application.

☞ Address all communications concerning station matters not to individual officers but to the Experiment Station, Burlington, Vt. Address inquiries concerning farm practice to Extension Service, Burlington, Vt.

Director's and State Forester's offices, chemical, horticultural and dairy laboratories are in Morrill Hall at the head of Main street; botanical and bacteriological laboratories are at Williams Science Hall, University Place; veterinary laboratories are at 499 Main street.

University farm and buildings are on the Williston road, adjoining the University grounds on the east.

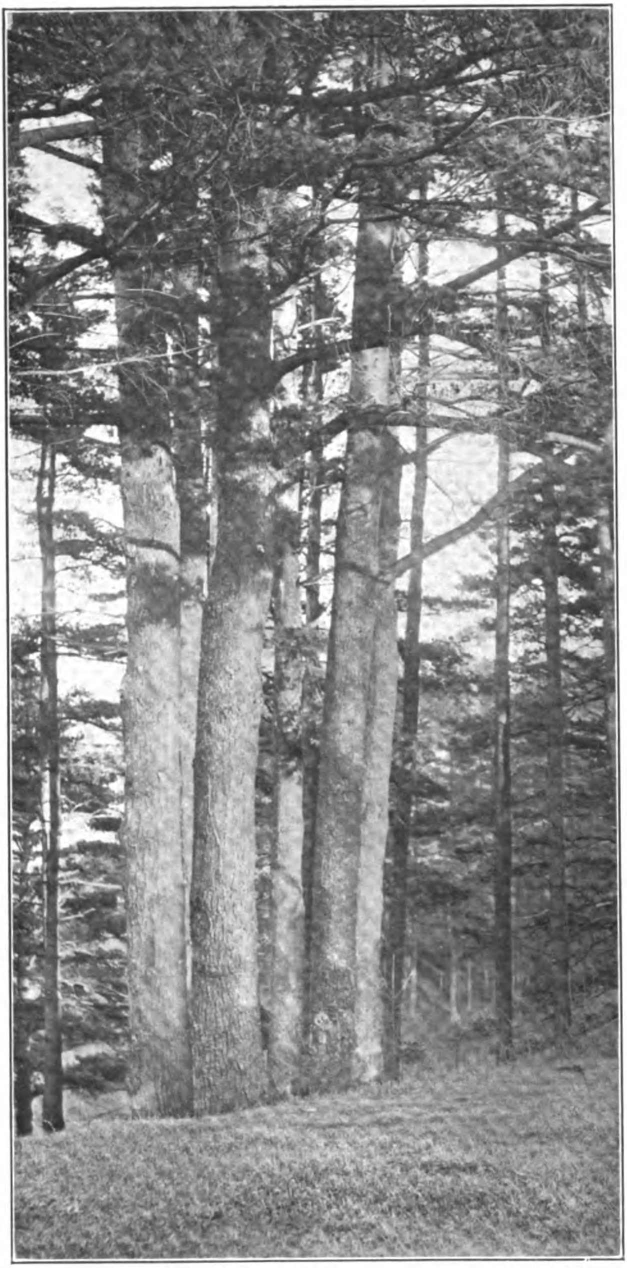

Photo by H. F. Perkins.

A NATURAL GROUP OF WHITE PINE ON THE GROUNDS OF THE UNIVERSITY OF VERMONT.

BULLETIN 194: THE TREES OF VERMONT

By G. P. Burns and C. H. Otis[1]

INTRODUCTION

The supply of bulletin 73, entitled "The Trees of Vermont," has been exhausted for several years. Repeated calls from all parts of the State and especially from the schools make it evident that its revision and reissue would be welcomed.

The present publication represents a revision of Bulletin 73 of the Vermont Agricultural Experiment Station, issued in 1899, and of Bulletin 16, Vol. XIV, N. S., of the University of Michigan, issued in 1913 under the authorship of the junior writer[2]. In the preparation of the present bulletin the authors have followed largely the general scheme and arrangement of the Michigan publication. Two chapters, "How to Study the Trees" and "Artificial Keys, How Made and Used," except for a few minor changes, are from the Michigan bulletin. The artificial keys for identification and the manual of trees have been adapted to the slightly different Vermont conditions. Most of the reproductions published in this bulletin have been made from new plates photographed from the drawings originally used to illustrate the Michigan bulletin. Credit has been indicated in each case. Finally, there have been added a series of bark photographs by the senior author, while the junior has contributed four original plates of drawings and accompanying descriptions and a section dealing with the identification and structure of Vermont woods. Upon the senior author has devolved the final bringing together of the component parts and the necessary editorial work involved.

This bulletin is intended primarily for the use of pupils in our public schools and of persons not especially trained in botany. For this reason the use of technical terms has been avoided whenever possible. In several cases such terms were necessary, but with the help of the glossary (page 233) their meaning can be easily understood.

The order of arrangement and nomenclature are essentially those of Gray's Manual. Following a tendency which is steadily gaining favor, all species names are printed with a small letter, regardless of their origin.

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[1] Professor Otis, formerly curator of the botanical garden and arboretum of the University of Michigan, spent several months during the past year at this institution, collaborating with the senior author in the preparation of this bulletin.

[2] The authors take this occasion to express their appreciation of the courtesy of the University of Michigan authorities in allowing them to make such liberal use of the material from the former bulletin in their present work.

Two sets of keys are given. One is based upon characters which are present during the summer; the other uses the winter characters as a basis for identification.

Photographs have not been used as illustrations because they are too indefinite and give all characters equal emphasis. This generally conceals the essential marks necessary for identification and affords little help to the student. Accurate line drawings are substituted for photographs, since they have proved to be much more serviceable in classwork.

It is believed that with the aid of the drawings and descriptions given in this bulletin any person will be able to identify any Vermont tree. If, however, difficulty is found in naming a given tree, specimens of flowers, fruit, leaves, wood, etc., mailed to the Extension Service, Burlington, Vermont, will be named without charge, if of such a character and received in such condition as will admit of identification.

HOW TO STUDY THE TREES

Trees are such familiar objects that the people who dwell in nearly every portion of this country see them daily. Trees give cooling shade in our parks and dooryards and along our highways; they lend their beauty to the landscape and relieve it of monotony; they yield many kinds of fruits, some of which furnish man and the animals of the forest with food; and they furnish vast quantities of lumber for a multitude of uses. It is important then that every person, whether in the schools or beyond school age, should become acquainted with our trees. Most people know a few of the more common trees but are ignorant of the great wealth of trees of various kinds about them. Some persons who may have wished to learn more have been hindered for lack of a teacher and others have been dismayed by the very multitude of manuals to which they have had access.

In beginning a study of trees the student should be careful to confine himself to well established facts. Once started he should proceed slowly, assimilating each new discovery before seeking another. He should begin with the trees nearest home and then becoming familiar with these in all their aspects, he should extend his trips afield. Not only should he be able to name the trees when they are fully clothed in summer garb, but he should know as readily the same trees when only the bare branches stand silhouetted against the sky if he desires to gain a thorough knowledge of his subject.

The characters which are used in studying the trees are habits, leaves, flowers, fruits, buds, bark, distribution and habitat. These will be discussed briefly in the next few pages, the same order that is used in the detailed descriptions of species being maintained in the present discussion. A few drawings also will be added to make certain points clear and to show comparative forms.

NAME.—Every tree has one or several common names and a scientific or Latin name. Some of these common names are merely local, while others have a more extended use. A few names apply to totally different species. Thus, cottonwood in Vermont is *Populus deltoides,* in Idaho and Colorado *Populus angustifolia,* in California *Populus fremontii* and in Kentucky *Tilia heterophylla.* While it should not be forgotten that in common speech it is proper as well as convenient to call trees by their common names, yet, in view of the many uncertainties pertaining to their use, a scientific name at times is absolutely essential to the clear understanding of what is meant. Latin is the language in universal use by all scientists. No longer used by any civilized nation, it has become a dead language and consequently never changes. Its vocabulary and its constructions a thousand years hence will probably be the same that they are today. Being in universal use among scientists of all nationalities no confusion arises from the use of a Latin word. The oak in Germany is known as *Eiche,* in France as *chêne* and in Spain as *roble,* but the Latin word *Quercus* is the same in all these countries.

A scientific name as applied to trees consists at least of two parts, as *Quercus alba.* The first is the genus name and always is written with a capital letter, the second is the species name and is written with a small letter, the two names constituting the briefest possible description of the particular tree. It is customary to add to these the name or an abbreviation of the name of the person who first gave the name to the tree, as *Quercus alba* L., the abbreviation standing for Linnaeus. Sometimes a third name is used, as *Acer saccharum nigrum,* referring in this instance to a variety of the ordinary Sugar Maple. In some cases trees have more than one Latin name. When this is true the synonym or synonyms are placed in brackets after the accepted name.

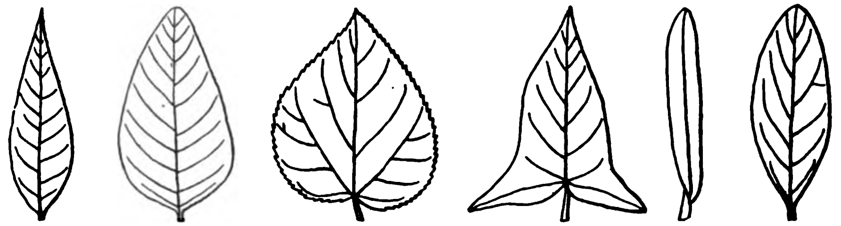
Genera which bear a relationship to each other are placed in the same family, the family name always having the characteristic ending—*aceae.* Related families again are grouped into orders, with the characteristic ending—*ales.* Orders in like manner are arranged into larger groups, called classes, and the latter into still larger groups, divisions, etc., each with its characteristic ending. Thus, *Acer saccharum nigrum* (Michx. f.) Britt. is classified as follows:

- Division—Spermatophyta
  - Subdivision—Angiospermae
    - Class—Dicotyledoneae
      - Order—Sapindales
        - Family—Aceraceae
          - Genus—Acer
            - Species—saccharum
              - Variety—nigrum.

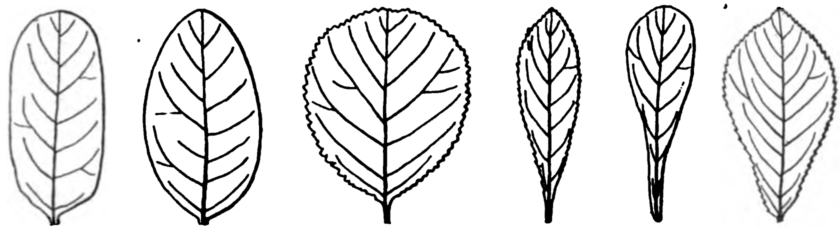
HABIT.—Habit, or the general appearance of a plant, is an important character of identification, especially as we become more and more familiar with the trees. Two main types are recognized, based on the manner of the branching of the trunk, the upright and the spreading. In the one the trunk extends straight upwards without dividing, as is typical in most of the conifers; in the other the trunk divides to form several large branches and the broad, spreading crown of most of our broad-leaf trees. In either case the crown may be regular in outline or very irregular, straggling or straight-limbed. Moreover, the tree growing in the open, where there is no crowding and plenty of light, may differ greatly from the tree in the forest, where the struggle for existence becomes very keen. A short, thick trunk and a low, spreading, many-branched crown characterize the tree in the open, whereas the forest tree has a long, slender, clean trunk and a narrow crown of few branches. In the descriptions of trees in this bulletin, unless otherwise stated, the habit in the open is the one given. Again, the tree may have been injured by storm or insect at some period of its growth and its natural symmetry destroyed. Moreover, the age of a tree has a great influence on its outline, young trees generally being narrow and more or less conical, broadening out as they become older. We may say, then, that each tree has an individuality of its own, little eccentricities similar to those that make people different from one another. And just as we have little difficulty in recognizing our friends at a distance by some peculiarity of walk or action, so we are able to recognize many trees at a distance by some peculiarity of form or habit.

LEAVES.—With the advent of spring the buds of our broad-leaf trees swell and burst and the leaves come forth and clothe the trees with mantles of green, hiding the branches which have been bare through the cold winter months. The evergreens, too, take on fresh color and commence a new period of growth. The beginner in botanical study finds the leaves the most interesting portion of a tree and one which affords him a ready means of identification. It must be remembered, however, that leaves vary greatly in size, shape and general appearance. For example, the leaves on a flourishing sprout are usually relatively large, whereas they may be much smaller on a stunted tree of the same species growing nearby and subjected to adverse circumstances.

I. LEAF OUTLINES



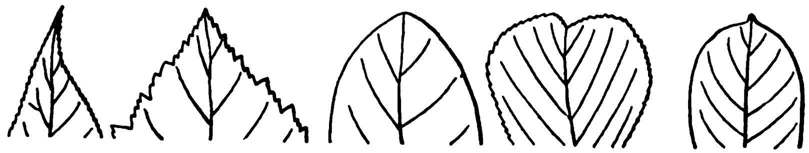
Lanceolate. Ovate. Heart-shaped. Halberd-shaped. Linear. Elliptical.



Oblong. Oval. Orbicular. Oblanceolate. Spatulate. Obovate.

The leaves of a big white oak standing in the yard may be hardly lobed on the lowermost branches, while higher up they are deeply cut. However, in spite of the many modifications they undergo, the leaves of any one species have certain rather constant characteristics which are found in all forms, and the student who has once learned what these are will have little difficulty in selecting and recognizing typical specimens.

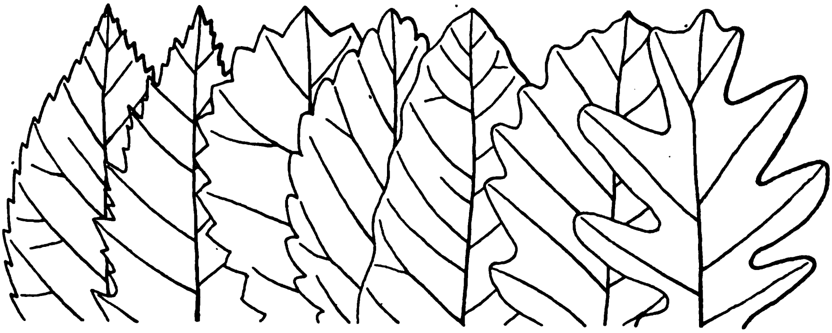
II. LEAF TIPS



Acuminate. Acute. Obtuse. Emarginate. Mucronate.

Leaves are either persistent, as in most of our conifers, which remain green all winter, or they assume various colors with the coming of the frost, and drop to the ground early in autumn although often they hang dead and lifeless far into the winter. The characteristics of leaves which we are accustomed to consider in determining their relationships are their position or arrangement on the branch, whether simple or compound, size, shape, texture, color, the amount and character of pubescence, the character of the margin, venation, etc. The following diagrams will serve to illustrate some of the ordinary forms and shapes of leaves, their margins, etc.

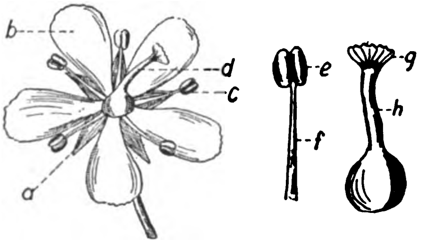
III. LEAF MARGINS



Serrate. Doubly Serrate. Dentate. Crenate. Undulate. Sinuate. Lobed.

Flowers.—Every tree when old enough bears flowers in its proper season. Some of these, as the hawthorns, locusts and horse-chestnuts, are very showy; others, like the oaks and hickories, are comparatively inconspicuous. Some are brilliantly colored, while others are of the same color as the leaves. Nevertheless, the flowers are very accurate means of classification, and the only drawback to their use for this purpose is the fact that they last for such a little while each year.

IV. PARTS OF A FLOWER

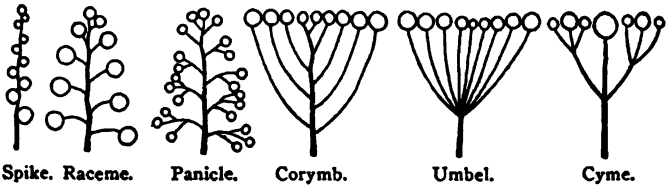


Perfect Flower. Stamen. Pistil.

a. Sepal (Calyx).
b. Petal (Corolla).
c. Stamen.
d. Pistil.
e. Anther.
f. Filament.
g. Stigma.
h. Style.
i. Ovary.

Just as there are male and female in the animal world, so the male and the female are found in the plant world. A few of our trees, as the locust, basswood and cherry, have perfect flowers, bearing both stamens and pistil. The great majority, however, have unisexual flowers, bearing either stamens or pistils, but not both. When both male and female flowers are found on the same tree, the flowers are said to be monoecious, and when male flowers occur on one tree and the female on a different tree, the flowers are said to be dioecious. The cottonwood of New England is dioecious and each little seed is surrounded by a tuft of long, white hairs which enables the wind to carry it considerable distances from the parent tree, to the disgust of people living within its range. The planting of the cottonwood is forbidden within the bounds of several cities on account of this objection. Since it is desirable in some places to plant this rapidly growing tree, as in cities burning large amounts of soft coal, it is a distinct advantage to know that the male trees may be planted safely, since they bear no seed and shed no "cotton."

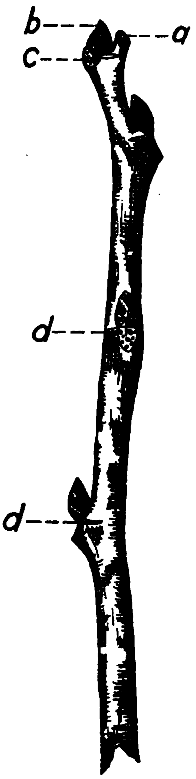
V. TYPES OF INFLORESCENCES



Before trees can produce fruit their flowers must be fertilized, i. e., pollen from the anther of a stamen must come in contact with the stigma of a pistil. Some flowers are self-fertilized and others are cross-fertilized. For a long time it was not understood how fertilization was accomplished, but now we know that many insects, like the nectar-loving bees and butterflies, and in other instances the wind, transport the pollen from one flower to another, often miles being traversed before the right kind of flower or a flower in the right stage of development is found. And many are the modifications of flowers to insure this transference of pollen.

FRUIT.—So numerous and so varied are the forms of tree fruits that it would be only confusing to state their characters. Some fruits, such as the achenes of the poplars and willows, are so small and light that they are carried long distances by the wind; others, like the hickory nuts and walnuts, are too heavy to be wind-blown. Many fruits are of considerable economic and commercial importance and are gathered and marketed on a large scale. Among these are the hickory nuts, walnuts, chestnuts, etc. Some, not esteemed by man, form an important article of diet for the birds and small animals of the forest. Unfortunately there are a number of limitations to the usefulness of fruit for identification purposes. Some trees require years to mature their fruit. Many trees, while producing an abundance of fruit at certain intervals, bear none at all or only very small and uncertain quantities between the years of abundance. Again, in the case of dioecious trees, only the female or pistillate bear fruit. Notwithstanding these limitations tree fruits are a very valuable aid to the student, and he should always search closely for evidences of their presence and character.

VI. WINTER TWIG OF RED MULBERRY

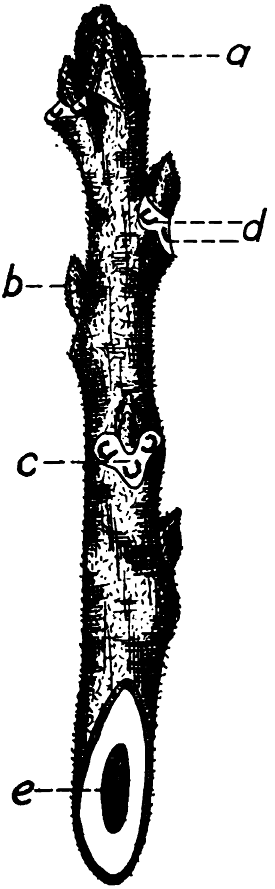


a. Tip-scar.
b. Lateral bud.
c. Leaf-scar.
d. Stipule-scars.

WINTER-BUDS.—Buds, with their accompanying leaf- and stipule-scars, form the basis of tree identification in winter. The size, color, position with reference to the twig, number and arrangement and character of bud-scales, etc., all are characters of the greatest value in winter determinations. Buds either are terminal or lateral, depending on their position on the twig. A lateral bud is one situated on the side of a twig in the axil of a leaf-scar. A terminal bud is one situated at the end of a twig, where it is ready to continue the growth of the twig the following spring. To the presence or absence of the terminal bud is accorded much importance in the keys on pages 162 and 163, which enable one more surely to identify a tree. Inasmuch as the determination of this point gives the beginner some trouble at first, it is hoped that the accompanying diagrams and explanatory remarks will serve to make the distinction clear.

In the elms, willows, basswood and many other species the terminal bud and a small portion of the tip of the twig dies and drops off in late autumn, leaving a small scar at the end of the twig (a, fig. VI). The presence of this tip-scar indicates that the terminal bud is absent. Often a lateral bud will be found very close to the tip-scar (b, fig. VI), which, bending into line with the twig, makes it appear to be a terminal rather than a lateral bud. However, the presence of a leaf-scar immediately below it shows it to be a lateral bud (c, fig. VI). The unaided eye can discern the tip-scars on some of the larger twigs, but a hand lens will be found necessary when the smaller twigs are under observation.

VII. WINTER TWIG OF BLACK WALNUT



a. Lateral bud.
b. Lateral bud.
c. Leaf-scar.
d. Bundle-scars.
e. Pith.

The arrangement, size and shape of the leaf-scars (c, fig. VII) are important factors in identification by winter characters. Within the leaf-scars are one or more dots (d, fig. VII), sometimes quite inconspicuous, often very prominent. These are the scars left by the fibro-vascular bundles which run through the petiole into the blade of the leaf, and are designated as bundle-scars. There may be many as in the oaks, three as in the poplars and cherries, or only one as in tamarack and the spruces; and they may be arranged in a U- or V-shaped line, or they may be without definite order. Often stipule-scars (d, fig. VI) occur on either side of the leaf-scar and are caused by the fall of a pair of small leaflets called stipules, located at the base of the leaves. Their form varies according to the form of the stipules which made them

BARK.—The woodsman uses the bark more than any other feature in identifying trees, and often he is able in this manner to distinguish trees with much accuracy at great distances. However, the appearance of bark differs so greatly with the age of the tree and with its environment that it is difficult to describe it accurately. Some characters are distinctive, however, and serve as a ready means of identification; as for example the peeling of the sycamore and paper birch, the "shelling" of the shellbark hickory and the mucilaginous inner bark of the slippery elm.

WOOD.—Under this heading are exhibited some of the general characteristics of wood. While it is not expected that this information will be of any particular value to the student of tree botany in identifying living trees, it happens often that such a one finds himself in the midst of felling operations or in the lumberyards; and under such circumstances a knowledge of the wood characters may be of considerable value. Few, if any, manuals or bulletins have been published dealing in a simple but comprehensive manner with the structure of wood. Especially is this true of the photographs or drawings accompanying such works. It hardly comes within the scope of this bulletin to discuss in detail all the woods of all the tree species growing in Vermont, although such a study doubtless would be worth while. Yet there does seem to be an urgent demand for such a publication dealing with our more common trees; and hence a detailed study has been made of such of our woods as are of importance from a lumbering standpoint. Illustrations, showing cross-, radial- and tangential-sections, accompanied by descriptions and keys, have been brought together in a chapter at the end of the manual proper, to which are referred persons desirous of a more thorough acquaintance with our commercial woods.

DISTRIBUTION AND HABITAT.—To a lesser extent do distribution and habitat of a species aid in the identification of a tree. It is a distinct advantage to know that the wild plum is native in western Vermont only and that the black gum is limited to the southernmost portions of the state. So, too, knowing the water-loving habit of the swamp spruce, we would not expect to find it flourishing on a rocky mountain-top.

The characteristics, then, which are used to identify the trees about us are many. Not all will be available at any one time, and not all have been mentioned in the foregoing pages nor in the manual. It is our opinion, however, that the student will not be handicapped greatly by this lack of detail, but rather that he will take great interest and genuine pleasure in discovering these things for himself.

ARTIFICIAL KEYS, HOW MADE AND USED

An artificial key is a scheme for identifying any unknown object under consideration easily and quickly. This bulletin being devoted to the trees of Vermont, its keys are intended to make it possible for any person, even if his botanical training be meager, to determine what native trees grow about his home or farm or in any Vermont city park or woodlot. With certain modifications and within limitations they may prove useful in other localities as well.

Since many people are unfamiliar with the construction and use of keys for purposes of identification, it is the purpose of the following paragraphs briefly to outline the principles upon which they are built and the manner in which they are used.

The keys are based on the most striking similarities and differences manifested by the various parts of trees—twigs, buds, leaves, etc.—that is to say, those characters which stand out in bold relief, which catch the eye at first sight. Two alternatives are presented, either a character *is* or *is not* presented; these are the only choices possible. Indeed, further divisions are unnecessary and lead only to confusion and possible oversight. The two diametrically opposed characters are said to be coordinate in rank. In the keys they are preceded by the same letter or letters (*a* and *aa* or *b* and *bb,* etc.) and are set at the same distance from the left margin of the page. Often *a* and *aa,* or *b* and *bb* are divisible further into other groups; in every case the characters are opposed (a positive and a negative) and are given coordinate rank. It is desirable for mechanical reasons to divide the main divisions of the key more or less evenly, but this is not always feasible, nor should it be adhered to strictly.

The nature and use of a key may be made the more clear by a homely but concrete example. Let us suppose that it is desired to construct a key in order to distinguish from one another five houses in a city block. Three of these houses are built of wood, two of brick, and of the three wooden houses two are painted white and one brown. We may classify them as follows:

a. Houses wood.
  b. Body paint brown .... *Smith's house*
  bb. Body paint white.
    c. Trimmings green color .... *Jones' house*
    cc. Trimmings slate color .... *Brown's house*
aa. Houses brick.
  b. Roof gray slate .... *Johnson's house*
  bb. Roof red tile .... *Public library*

It is desirable in many instances to add other characters to lessen the likelihood of confusion, in cases where the characters chosen are not distinct, and in order to show the user that he is on the right track. Thus, in the example just given, green color and slate color might be confused owing to certain defects of the eye, to a coating of dust or deficiencies of the light. Hence we would be justified in adding to the above statements additional distinguishing characteristics. Thus:

bb.
 c. Trimmings green color; gable roof.............*Jones' house*
 cc. Trimmings slate color; mansard roof.........*Brown's house*

The keys in this bulletin are constructed on these principles. They are not always as simple as the illustration just used, but if the reader has mastered the house illustration he will have little or no trouble with the larger keys. In order that the usage of the keys may be made the more clear, the following example, couched in language using the personal pronoun, is set forth at some length. The reader is advised to trace it from beginning to end as a ready means of familiarizing himself with the use of and possibilities of the key system.

Suppose that during a summer stroll you come across a large tree with rough, flaky bark and thin, lobed leaves which you do not know. Turning to the *Summer Key to the Genera* on pages 16 to 19, you find first *a Leaves simple,* and contrasted with this *aa Leaves compound.* Obviously the leaf is simple and the genus sought lies in that portion of the key preceding *aa,* i. e., under *a.* The subdivisions, *b,* and *bb,* under *a* afford you a choice between *Leaves needle-shaped, awl-shaped, strap-shaped or scale-like* and *Leaves broad and flat.* The leaf being broad and flat you pass onwards in the key to *c* and *cc* under *bb.* Here you have a choice between *Leaves alternate or clustered* and *Leaves opposite.* Inspection shows the arrangement to be alternate, and you know that the genus sought lies in that portion of the key which lies between *c* and *cc.* Passing to *d* and *dd* under *c* you are offered the choice between *Margin of leaves entire or only slightly undulate* and *Margin of leaves serrate, toothed or lobed* and your observation clearly indicates that the leaf is neither entire nor undulate, hence are in *dd* class. Under *dd* you may choose between *e, Margin of leaves serrate to toothed* and *ee, Margin of leaves distinctly lobed.* The leaf being deeply lobed, you know that the genus sought is one of five lying between *ee* and *cc,* all of which have lobed leaves. To make the determination, you must look for the fruit, since *f* and *ff* under *ee* give a choice between *Fruit an acorn* and *Fruit not an acorn.* You poke about in the grass beneath the tree with your foot, finding an acorn, water-soaked and worm-eaten, and then another. But these may have been carried hither by an industrious squirrel or washed here by the rain or blown by the wind and deposited for the entrapment of the unwary. Hence you look up into the tree for affirmation and observing more closely than heretofore you note that the young, green acorns are quite apparent. The genus, then, is *Quercus.*

Before going further in your pursuit it will be well for you to go back over the key to make careful note of the particular characters which were used to separate this genus from the other genera and to try to fix these in mind. This being done, you should turn to the page indicated, where you will find a *Summer Key to the Species of Quercus.* You may then run through this key in the same manner that you did the genus key. If you have been careful in your search you will stop finally at *Quercus alba.* At this point you will do well once more to pause and go back over this key and try to fix in mind the characters which were used to separate the various species, especially the difference between your tree and *Quercus macrocarpa,* which it resembles so closely. This done, you will turn to the page indicated and compare the characters of your tree with the drawings and descriptions. If you are satisfied with your diagnosis, well and good. If you find that you are wrong, go over the keys again and find wherein you were led astray.

Before you leave the tree take a sample of leaf properly labeled which you can press between the pages of an old magazine and save for future reference. Do this with other trees which you may find and when you get home lay them out side by side so that the labels will not show and compare them. A few trials of this kind will serve to form a mental picture of each leaf which you will remember.

A very helpful practice for the beginner is that of making keys based upon various characters. Practice keys of this kind will bring out the differences and likenesses of trees as will no other means, and characters which hitherto have escaped the eye will be brought forward prominently. Nor should the student take his characters from books, but rather should go to the woods and get his knowledge at first hand.

It is hardly necessary to state that while the key is a valuable crutch while learning to walk, once the leg is strong enough to bear the weight it should be discarded, lest it becomes a burden. A key's main function is the guidance of the student through the preliminary steps leading to a more intimate knowledge of the trees.

SUMMER KEY TO THE GENERA

a. Leaves simple.

b. Leaves needle-shaped, awl-shaped, strap-shaped or scale-like.

c. Leaves in clusters of 2-many.

d. Leaves in clusters of 2-5 sheathed, persistent for several years .... **Pinus,** p. 25.

dd. Leaves in fascicles of 8-many, on short, lateral branchlets, deciduous in autumn.................. **Larix,** p. 35.

cc. Leaves solitary, not clustered.

d. Leaves opposite.

e. Twigs flattened; leaves all of one kind, scale-like, decurrent on the stem; fruit a small, pale brown cone, **Thuja,** p. 51.

ee. Twigs essentially terete; leaves of two kinds, either scale-like, or else awl-shaped, often both kinds on the same branch, not decurrent on the stem; fruit berry-like, bluish .... **Juniperus,** p. 53.

dd. Leaves alternate or spirally-whorled.

e. Leaves flattened, soft to the touch.

f. Leaves ½-1¼ inches long, sessile, aromatic; cones 2-4 inches long; bark of trunk with raised blisters containing resin .... **Abies,** p. 47.

ff. Leaves seldom over ½ inch long, short-petioled, not aromatic; cones about ¾ inch long; bark of trunk without raised blisters .... **Tsuga,** p. 49.

ee. Leaves 4-sided, harsh to the touch........ **Picea,** p. 37.

bb. Leaves broad and flat.

c. Leaves alternate or clustered, never opposite.

d. Margin of leaves entire or only slightly undulate.

e. Leaves 2-5 inches long; fruit a drupe or berry, **Nyssa,** p. 183.

ee. Leaves 5-9 inches long; fruit an acorn.. **Quercus,** p. 112.

dd. Margin of leaves serrate, toothed or lobed.

e. Margin of leaves serrate to toothed.

f. Branches armed with stiff, sharp thorns, **Crataegus,** p. 147.

ff. Branches not armed.

g. Base of leaves decidedly oblique.

h. Leaf-blades about as long as they are broad, heart-shaped; fruit globose, woody, ripe in autumn, **Tilia,** p. 181.

hh. Leaf-blades 1½-2 times as long as they are broad, oval to ovate; fruit a membranaceous samara, ripe in spring ....**Ulmus,** p. 129.

gg. Base of leaves essentially symmetrical.

h. Teeth coarse, 2-5 per inch of margin.

i. Leaves very glabrous both sides; fruit a prickly bur.

j. Leaves 3-5 inches long, very lustrous beneath; bark close, smooth, steel-gray..**Fagus,** p. 107.

jj. Leaves 6-8 inches long, not lustrous beneath; bark fissured, brownish....**Castanea,** p. 108.

ii. Leaves pubescent or white-tomentose, at least beneath; fruit not a prickly bur.

j. Leaves 2-4 inches long, broadly ovate to sub-orbicular; fruit a very small capsule, falling in spring ....**Populus,** p. 60.

jj. Leaves 4-7 inches long, oblong-lanceolate to obovate; fruit an acorn, falling in autumn, **Quercus,** p. 112.

hh. Teeth fine, 6-many per inch of margin.

i. Leaf-petioles laterally compressed; leaves tremulous ....**Populus,** p. 60.

ii. Leaf-petioles terete; leaves not tremulous.

j. Leaf-blades at least 3 times as long as they are broad.

k. Twigs brittle; fruit a very small capsule, falling in spring ....**Salix,** p. 55.

kk. Twigs tough; fruit a fleshy drupe, falling in late summer or autumn....**Prunus,** p. 149.

jj. Leaf-blades not more than twice as long as they are broad.

k. Leaf-blades about twice as long as they are broad.

l. Margin of leaves singly serrate; fruit fleshy.

m. Lenticels conspicuous; pith whitish or brownish; bark easily peeled off in papery layers; buds ovoid,
Prunus, p. 149.

mm. Lenticels inconspicuous; pith greenish; bark not separable into papery layers; buds narrow-conical,
Amelanchier, p. 145.

ll. Margin of leaves doubly serrate; fruit not fleshy.

m. Trunk fluted; fruit inclosed within a halberd-shaped involucre,
Carpinus, p. 95.

mm. Trunk not fluted; fruit not inclosed within a halberd-shaped involucre.

n. Bark of trunk gray-brown, broken into narrow, flattish pieces loose at the ends; fruit in hop-like strobiles,
Ostrya, p. 93.

nn. Bark of trunk white, yellow or dark brown, platy or cleaving off in papery layers; fruit not in hop-like strobiles ....**Betula,** p. 97.

kk. Leaf-blades almost as broad as they are long.

l. Lower side of leaves more or less downy; sap milky; leaves not crowded on short, spur-like branchlets; fruit berry-like, black ....**Morus,** p. 137.

ll. Lower side of leaves glabrous; sap not milky; leaves crowded on short, spur-like branchlets; fruit a large, green pome,
Pyrus, p. 143.

ee. Margin of leaves distinctly lobed.

f. Fruit an acorn.....................**Quercus,** p. 112.

ff. Fruit not an acorn.

g. Leaf-lobes entire; leaves lustrous above, their petioles 5-6 inches long......**Liriodendron,** p. 139.

gg. Leaf-lobes sinuate-toothed to serrate; leaves not lustrous above, their petioles 1-2 inches long.
  h. Leaf-lobes coarsely sinuate-toothed; winter-buds forming in summer within the petiole of the leaf, **Platanus,** p. 141.
  hh. Leaf-lobes serrate; winter-buds not forming in summer within the petiole of the leaf.
    i. Branches armed with stiff, sharp thorns; sap not milky .... **Crataegus,** p. 147.
    ii. Branches unarmed; sap milky,... **Morus,** p. 137.
cc. Leaves opposite .... **Acer,** p. 162.
aa. Leaves compound.
  b. Leaves alternate.
    c. Branchlets armed with short, sharp prickles.. **Robinia,** p. 159.
    cc. Branchlets unarmed.
      d. Upper leaflets less than 1 inch broad; fruit berry-like, ¼ inch in diameter .... **Pyrus,** p. 143.
      dd. Upper leaflets 1-5 inches broad; fruit a nut an inch or more in diameter.
        e. Leaflets 5-11; pith homogeneous.......... **Carya,** p. 83.
        ee. Leaflets 11-23; pith chambered.......... **Juglans,** p. 77.
  bb. Leaves opposite.
    c. Leaves pinnately compound; fruit a samara.
      d. Leaflets 3-5; samaras paired............... **Acer,** p. 162.
      dd. Leaflets 7-11, exceptionally 5; samaras not paired, **Fraxinus,** p. 185.
    c. Leaves digitately compound; fruit a prickly bur, **Aesculus,** p. 179.

WINTER KEY TO THE GENERA

a. Leaves persistent and green through the winter, needle-shaped, awl-shaped or scale-like.

b. Leaves in clusters of 2-5, sheathed............... **Pinus,** p. 25.

bb. Leaves solitary, not clustered.

c. Leaves opposite.

d. Twigs flattened; leaves all of one kind, scale-like, decurrent on the stem; fruit a small pale brown cone.. **Thuja,** p. 51.

dd. Twigs essentially terete; leaves of two kinds, either scale-like, or else awl-shaped, often both kinds on the same branch, not decurrent on the stem; fruit berry-like, bluish, **Juniperus,** p. 53.

cc. Leaves alternate or spirally-whorled.

d. Leaves flattened, soft to the touch.

e. Leaves ½-1¼ inches long, sessile, aromatic; cones 2-4 inches long; bark of trunk with raised blisters containing resin .... **Abies,** p. 47.

ee. Leaves seldom over ½ inch long, short-petioled, not aromatic; cones about ¾ inch long; bark of trunk without raised blisters .... **Tsuga,** p. 49.

dd. Leaves 4-sided, harsh to the touch............ **Picea,** p. 37.

aa. Leaves not persistent and green throughout the winter, but deciduous in early autumn.

b. Twigs, branches or trunks armed with stiff, sharp spines or thorns.

c. Thorns or spines not exceeding ½ inch in length on the branches, in pairs at each node; buds rusty-hairy, 3-4 superposed; fruit a flat pod .... **Robinia,** p. 159.

cc. Thorns or spines much exceeding ½ inch in length on the branches, not in pairs at each node; buds not rusty-hairy, not superposed; fruit a pome .... **Crataegus,** p. 147.

bb. Twigs, branches or trunks unarmed.

c. Leaf-scars mainly crowded on short, stout, lateral shoots; bundle-scar 1; fruit a cone .... **Larix,** p. 35.

cc. Leaf-scars distributed along the lateral branches; bundle-scars 3-many; fruit not a cone.

d. Leaf-scars 2 at a node, i. e., opposite.

e. Terminal buds ½-1½ inches long, resin-coated; twigs very stout .... **Aesculus,** p. 179.

ee. Terminal buds rarely exceeding ½ inch in length, not resin-coated; twigs not conspicuously stout.

f. Bundle-scars usually 3, distinct, separated . **Acer,** p. 163.

ff. Bundle-scars many, minute, more or less confluent in a U-shaped line .... **Fraxinus,** p. 185.

dd. Leaf-scars 1 at a node, i. e., alternate.

e. Bundle-scars 3 or in 3 compound, but distinct groups.

f. Terminal bud present.

g. Stipule-scars present.

h. First scale of lateral bud directly in front, i. e., exactly above the center of the leaf-scar; twigs brittle; pith somewhat star-shaped in cross-section .... **Populus,** p. 61.

hh. First scale of lateral bud not directly in front, i. e., to one side of the center of the leaf-scar; twigs not brittle; pith circular in cross-section, **Prunus,** p. 149.

gg. Stipule-scars absent.

h. Buds bright to dark red, the terminal ⅛-¼ inch long .... **Nyssa,** p. 183.

hh. Buds brownish to gray, the terminal exceeding ¼ inch in length.

i. Buds narrow-conical, sharp-pointed; leaf-scars small, narrowly crescent-shaped; twigs about 1/16 inch thick; pith homogeneous; fruit berry-like, not present.............. **Amelanchier,** p. 145.

ii. Buds broadly conical to ovoid, blunt-pointed; leaf-scars conspicuous, broadly heart-shaped; twigs about ¼ inch thick; pith chambered; fruit a nut, often present........... **Juglans,** p. 77.

ff. Terminal bud absent (sometimes present on short shoots of *Betula*).

g. Stipule-scars present.

h. Bud-scale only 1 visible; twigs brittle, **Salix,** p. 55.

hh. Bud-scales 2 or more; twigs not brittle.

i. Bark smooth, close, warty or peeling off in papery layers, but not flaky nor rough-ridged.

j. Trunk fluted; catkins not present in winter; lenticels not elongated horizontally; low tree or bushy shrub .... **Carpinus,** p. 95.

jj. Trunk not fluted; catkins usually present in winter; lenticels elongated horizontally; large trees .... **Betula,** p. 97.

ii. Bark flaky or rough-ridged, not warty nor peeling off in papery layers.

j. Bundle-scars depressed, conspicuous; bark thick, more or less deeply furrowed, **Ulmus,** p. 129.

jj. Bundle-scars not depressed, inconspicuous; bark thin, broken into narrow, flattish strips, loose at the ends............. **Ostrya,** p. 93.

gg. Stipule-scars absent.................. **Prunus,** p. 149.

ee. Bundle-scars 4-many.

f. Bundle-scars in a single U-shaped line.

g. Terminal bud present; fruit berry-like; a shrub or small tree .... **Pyrus,** p. 143.

gg. Terminal bud absent; fruit not berry-like; large trees.

h. Stipule-scars encircling the twig; leaf-scars nearly surrounding the bud; bark peeling off in thin plates, exposing the lighter colored inner bark, **Platanus,** p. 141.

hh. Stipule-scars not encircling the twig; leaf-scars not nearly surrounding the bud; bark thick, rough-ridged, not exposing the inner bark, **Ulmus,** p. 129.

ff. Bundle-scars variously grouped or scattered, but not in a single line.

g. Terminal bud present.

h. Stipule-scars present.

i. Stipule-scars encircling the twig; visible bud-scales 2, united....... **Liriodendron,** p. 139.

ii. Stipule-scars not encircling the twig; visible bud-scales more than 2, not united.

j. Buds 4 times as long as broad, not clustered at the tips of vigorous shoots; fruit a prickly bur .... **Fagus,** p. 107.

jj. Buds not 4 times as long as broad, usually clustered at the tips of vigorous shoots; fruit an acorn .... **Quercus,** p. 113.

hh. Stipule-scars absent .... **Carya,** p. 83.

gg. Terminal bud absent (occasionally present in *Castanea*).
  h. Bud at end of twig very obliquely unsymmetrical, mucilaginous when chewed........**Tilia,** p. 181.
  hh. Bud at end of twig symmetrical, not mucilaginous when chewed.
    i. Bud-scales 2-3 visible; pith star-shaped in cross-section; sap not milky; fruit a prickly bur, present; large tree ....**Castanea,** p. 108.
    ii. Bud-scales 4-8 visible; pith not star-shaped in cross-section; sap milky; fruit berry-like, not present; small tree............**Morus,** p. 137.

PINACEAE—PINE FAMILY

THE PINES

The pines are the largest and most useful group of trees included in the great cone-bearing family. There are nine different species in the eastern United States, four of which are found in Vermont.

The pines, like the other members of this family, produce their seeds in cones. They are peculiar, however, in that their cones require two years for maturing. The flowers also take the form of cones, the pollen-bearing and the ovule-bearing clusters being separated, though both may be found on the same tree. The yellow pollen matures in May or June, when it is scattered in great abundance, to be borne to its destination by the wind. Most of the seed-bearing cones develop on the upper branches, and the nut-like seeds escape from them during the second autumn. The empty cones with opened scales thereafter may cling to the tree for some time or they may fall soon.

The leaves of all the evergreens cling to the branches several years. The leaves of the white pine, for example, drop when they are three or four years old. The arrangement of the leaves, or needles, in clusters of from two to five, with the base of each cluster encased in a delicate sheath, offers a simple means of distinguishing the species.

Introduced species.—Two European pines, the Austrian and the Scotch, are often planted in Vermont as forest trees as well as for ornamental purposes. The Scotch pine has leaves two in a cluster, 2-4 inches long, flat and of a bluish-white hue. The Austrian pine has dark green, slender, rigid leaves, two in a cluster, 4-6 inches long.

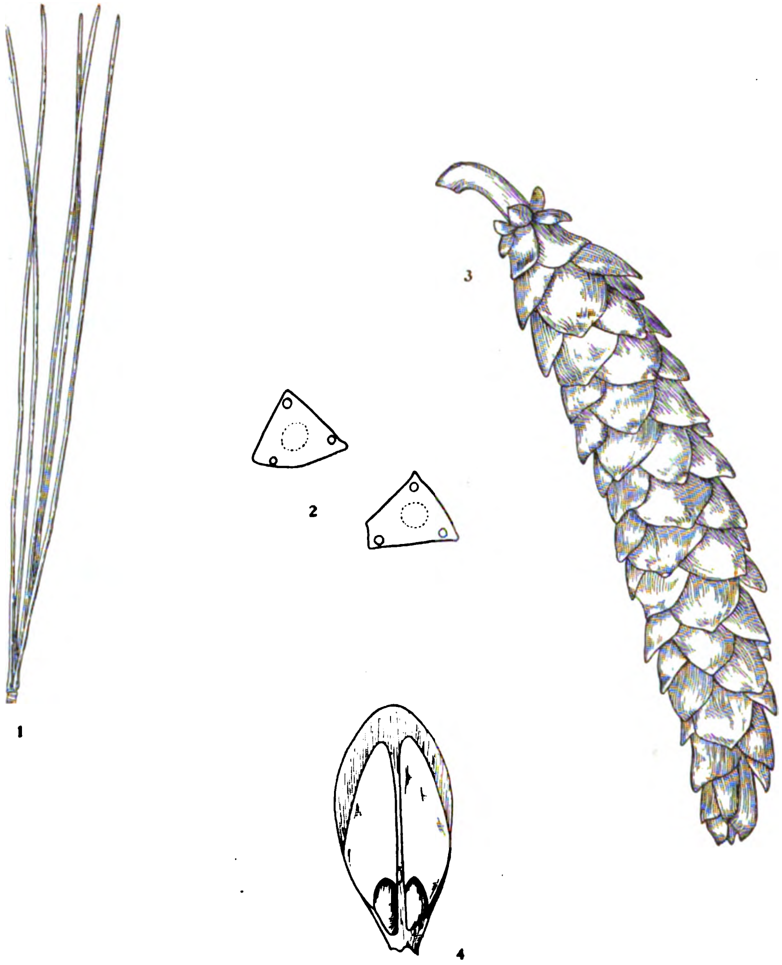
SUMMER AND WINTER KEY TO THE SPECIES OF PINUS

a. Leaves 5 in a cluster; cones 4-10 inches long . . . . **P. strobus,** p. 27.

aa. Leaves not 5 in a cluster; cones less than 4 inches long.

- *b*. Leaves 2 in a cluster; cone-scales unarmed, or at most provided with minute prickles.
  - *c*. Leaves less than 4 inches long (about 1 inch), strongly divergent; cones pointing forward towards the tip of the branch, persistent 10-15 years, opening very unevenly, **P. banksiana,** p. 31.
  - *cc*. Leaves 4-6 inches long, not strongly divergent; cones not pointing forward towards the tip of the branch, not persistent 10-15 years, but opening in the autumn of the second season and falling the next summer . . . . **P. resinosa,** p. 33.
- *bb*. Leaves 3 in a cluster; cone-scales armed with conspicuous prickles . . . . **P. rigida,** p. 29.

White Pine



(Mich. Trees).

1. Cluster of leaves, x 1.
2. Cross-sections of leaves, enlarged.
3. Partly opened cone, x ¾.
4. Cone-scale with seeds, x 1.

PINACEAE

White Pine

Pinus strobus L.

HABIT.—A large tree 60-80 feet high, with a trunk diameter of 2-4 feet; forming a wide, pyramidal crown. Formerly trees 100-150 feet in height and 5-7 feet in trunk diameter were not exceptional.

LEAVES.—In clusters of five; 3-5 inches long; slender, straight, needle-shaped, 3-sided, mucronate; pale blue-green. Persistent about 2 years.

FLOWERS.—June; monoecious; the staminate oval, light brown, about ⅓ inch long, surrounded by 6-8 involucral bracts; the pistillate cylindrical, about ¼ inch long, pinkish purple, long-stalked.

FRUIT.—Autumn of second season, falling during the winter and succeeding spring; pendent, short-stalked, narrow-cylindrical, often curved, greenish cones, 4-10 inches long; scales rather loose, slightly thickened at the apex; seeds red-brown, ¼ inch long, with wings 1 inch long.

WINTER-BUDS.—Oblong-ovoid, sharp-pointed, yellow-brown, ¼-½ inch long.

BARK.—Twigs at first rusty-tomentose, later smooth and light brown, finally thin, smooth, greenish; thick, dark gray on the trunk, shallowly fissured into broad, scaly ridges. Plate I.

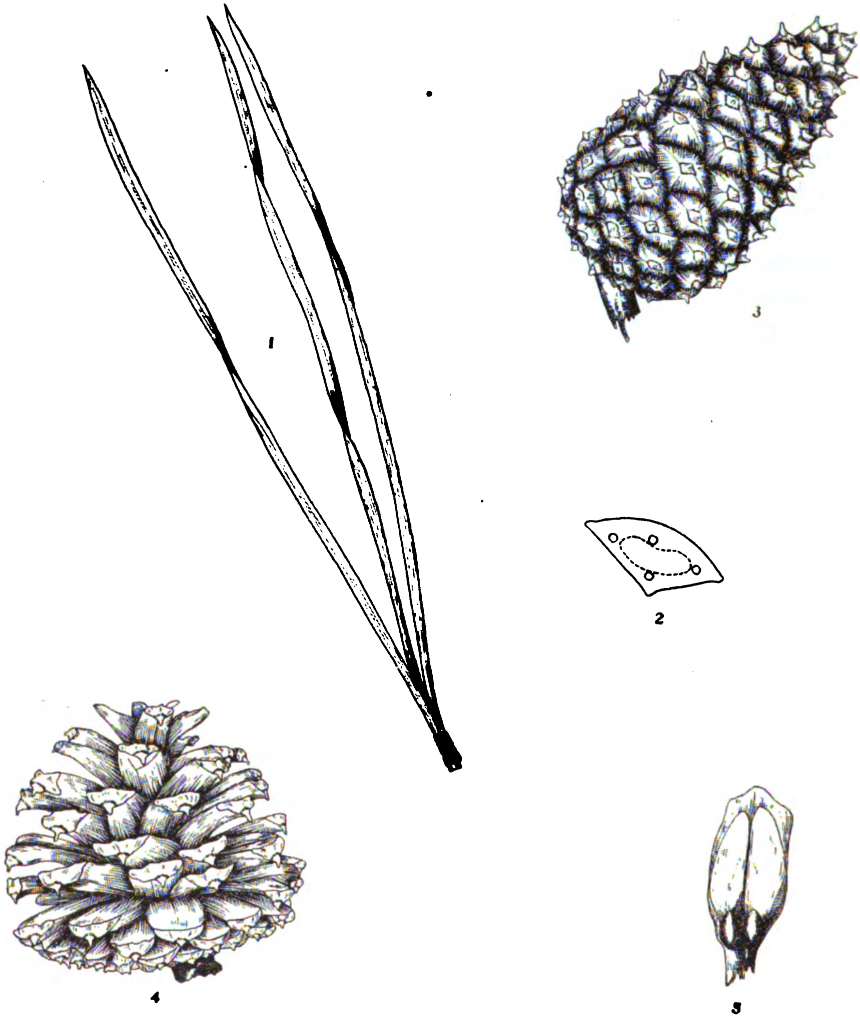
WOOD.—Light, soft, weak, compact, straight-grained, easily worked, light brown, with thin, whitish sapwood. Page 215.

DISTRIBUTION.—Common throughout the state up to 1,000 feet altitude, but most abundant in the Champlain and Connecticut valleys.

HABITAT.—Prefers a light, fertile loam; sandy soils of granite origin.

NOTES.—The white pine, growing as it does sometimes to immense height, was one of the loftiest trees of the primeval New England forest. Lumbermen have removed most of the patriarchs and only the younger trees commonly remain. Its slender lustrous leaves are borne in close clusters and give it a beauty and delicacy of foliage possessed by no other pine. It is one of the most valuable and most rapidly growing of Vermont's timber trees and is being planted every year by the thousands in our state forests and by private owners.

Pitch Pine



1. Cluster of leaves, x 1.
2. Cross-section of leaf, enlarged.
3. Unopened cone, x 1.
4. Opened cone, x 1.
5. Cone-scale with seeds, x 1.

PINACEAE

Pitch Pine

Pinus rigida Mill.

HABIT.—A small tree 40-60 feet high, with a short, crooked trunk 1-2 feet in diameter; coarse, gnarled branches form an irregular, open, pyramidal or rounded crown; a decidedly scraggly tree.

LEAVES.—In clusters of three; 2-5 inches long; stout, stiff, tapering to a thick tip; more or less twisted, divergent from a short sheath; bright yellow-green. Persistent 2-3 years.

FLOWERS.—May-June; monoecious; the staminate in short, crowded, cylindrical spikes about ¾ inch long, yellowish; the pistillate lateral, subglobose, short-stalked, more or less clustered, reddish-green, about ⅛ inch long.

FRUIT.—Autumn of second season, opening soon after, but persistent on the tree for 10-12 years; lateral, at about a right angle to the branch, either solitary or in whorls of several; ovoid to nearly globose, nearly sessile cones 1-3 inches long; scales thickened at the apex and armed with a stiff, recurved prickle; seeds triangular, dark brown, ¼ inch long, with wings about ½ inch long.

WINTER-BUDS.—Cylindrical to ovoid, sharp-pointed, dark red-brown, about ½ inch long.

BARK.—Twigs smooth, light green, becoming yellow, finally dark gray-brown and rough with the persistent bases of fallen leaves; thin, red-brown on the trunk, with broad, flat ridges and deepish furrows. Plate I.

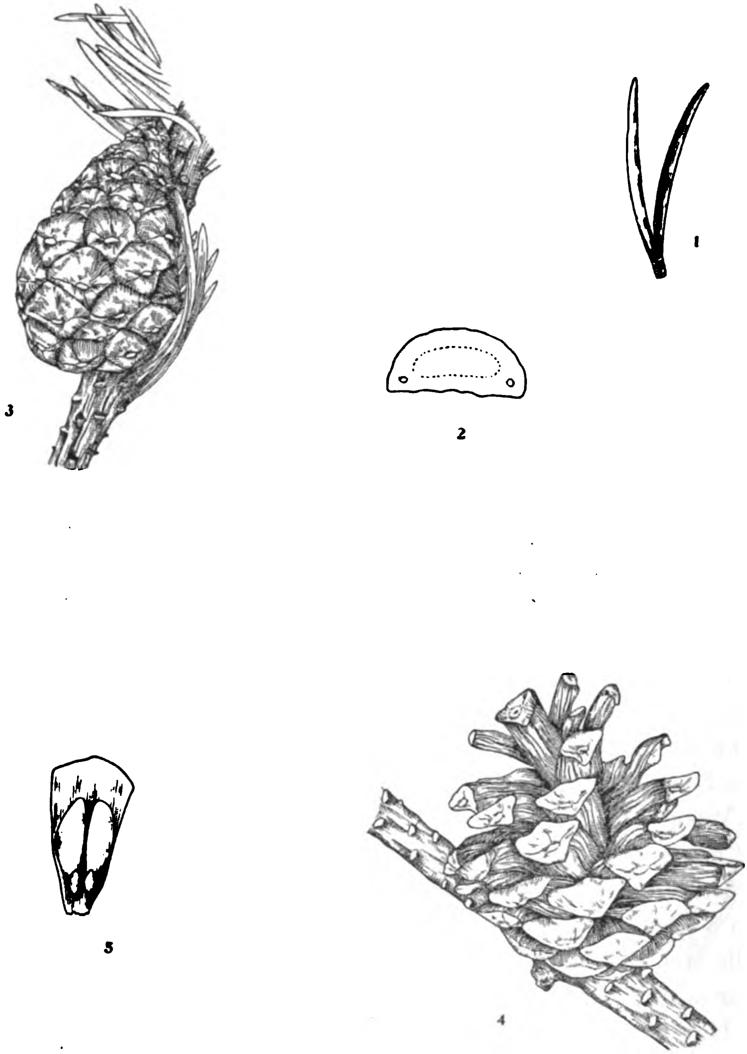
WOOD.—Light, soft, weak, brittle, coarse-grained, very durable, light brown or red, with thick, yellowish to whitish sapwood.

DISTRIBUTION.—Common in the northern portion of the Champlain Valley, especially along the lower courses of the Winooski, Lamoille and Missisquoi Rivers; less common in the Connecticut Valley as far north as Wells River.

HABITAT.—Barren, sandy soil.

NOTES.—This tree is a prolific seeder. It is able to sprout from the stump and is fire-resistant. In suitable places it forms dense groves of small trees, forty to sixty feet in height. The individual trees sometimes are picturesque but neither graceful nor very attractive in appearance. The branches even of the smaller trees mature numerous cones, which are long persistent. They are about two inches long, and, as has been said, they have scales tipped with sharp recurved prickles, a character which may aid in its recognition.

Gray Pine. Jack Pine



(Mich. Trees).

1. Cluster of leaves, x 1.
2. Cross-section of leaf, enlarged.
3. Branchlet with unopened cone, x 1.
4. Branchlet with opened cone, x 1.
5. Cone-scale with seeds, x 1.

PINACEAE

Gray Pine. Jack Pine

Pinus banksiana Lamb. [Pinus divaricata (Ait.) DuMont de Cours.]

HABIT.—Usually a small tree 15-30 feet high, with a trunk diameter of 8-12 inches; forming usually a scrubby, stunted, and variously distorted crown.

LEAVES.—In clusters of two; about 1 inch long; narrow-linear, with sharp-pointed apex; stout, curved or twisted, divergent from a short sheath; dark gray-green. Persistent 2-3 years.

FLOWERS.—May-June; monoecious; the staminate in oblong clusters ½ inch long, composed of many sessile, yellow anthers imbricated upon a central axis; the pistillate in subglobose clusters, composed of many carpel-like, purple scales (subtended by small bracts) spirally arranged upon a central axis.

FRUIT.—Autumn of second or third season, but remaining closed for several years and persistent on the tree for 10-15 years; erect, usually incurved, oblong-conical, sessile cones, 1½-2 inches long; scales thickened at the apex; seeds triangular, nearly black, ⅜ inch long, with wings ⅓ inch long.

WINTER-BUDS.—Terminal bud ¼ inch long, ovoid, rounded, pale brown; lateral buds smaller.

BARK.—Twigs yellow-green, becoming purple, finally dark red-brown and rough with the persistent bases of fallen leaves; thin, dark red-brown on the trunk, with shallow, rounded ridges, rough-scaly on the surface.

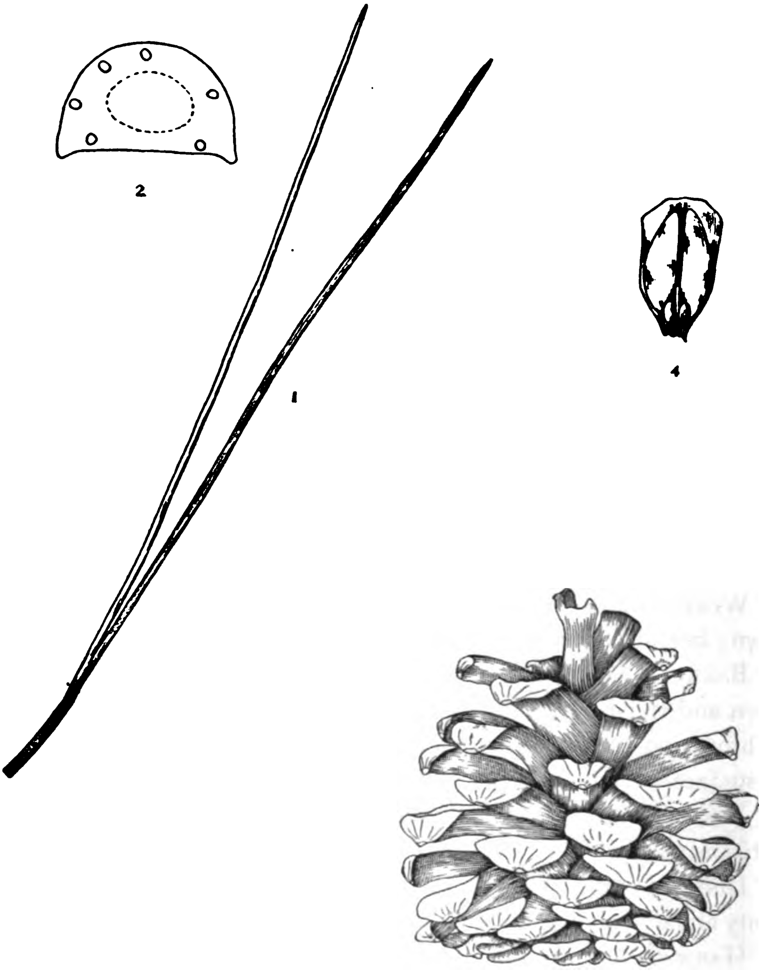
WOOD.—Light, soft, weak, close-grained, light brown, with thick, whitish sapwood.

DISTRIBUTION.—Reported at Monkton and Starksboro in Addison county and at Fairfax in Franklin county; but few trees at each station.

HABITAT.—Sandy, sterile soil; rocky slopes.

NOTES.—The gray pine is the smallest of the Vermont pines, with sprawling habit and short stout leaves, giving the tree a bristly, stunted appearance. Its characteristic cones are pointed and curved toward the main axis of the stem, often partially encircling it. The gray pine is a northern species extending to the Arctic region, and the line of its southeastern limit passes through northern Vermont. It is one of the rarest of our trees, and but few specimens are known to occur within our State borders. The remaining trees should be sought out and spared because of their scientific interest.

Red Pine. Norway Pine



(Mich. Trees).

1. Cluster of leaves, x 1.
2. Cross-section of leaf, enlarged.
3. Opened cone, x 1.
4. Cone-scale with seeds, x 1.

PINACEAE

Red Pine. Norway Pine

Pinus resinosa Ait.

HABIT.—A large tree 50-75 feet high, with a trunk diameter of 2-3 feet; stout, horizontal branches form a broad, rounded, rather open crown.

LEAVES.—In clusters of two; 4-6 inches long; slender, straight, needle-shaped, sharp-pointed, flexible, from elongated, persistent sheaths; lustrous dark green. Persistent 4-5 years.

FLOWERS.—April-May; monoecious; the staminate in oblong, dense clusters, ½-¾ inch long, composed of many sessile, purple anthers imbricated upon a central axis; the pistillate single or few-clustered at the end of the branchlets, subglobose; scales ovate, scarlet, borne on stout peduncles covered with pale brown bracts.

FRUIT.—Autumn of second season, falling the next summer; ovate-conical, nearly sessile cones, about 2 inches long; scales thickened at the apex; seeds oval, compressed, light mottled-brown, with wings ½-¾ inch long.

WINTER-BUDS.—About ¾ inch long, ovoid or conical, acute, red-brown, with rather loose scales.

BARK.—Twigs orange-brown, becoming rough with the persistent bases of leaf-buds; thick and red-brown on the trunk, shallowly fissured into broad, flat ridges. Plate I.

WOOD.—Light, hard, very close-grained, pale red, with thin, yellow to white sapwood. Page 217.

DISTRIBUTION.—Scattered groups or small groves occur on the dry, rocky headlands of Lake Champlain and it may be found in similar soils in the river valleys throughout Vermont, although it is less frequent in the southern counties.

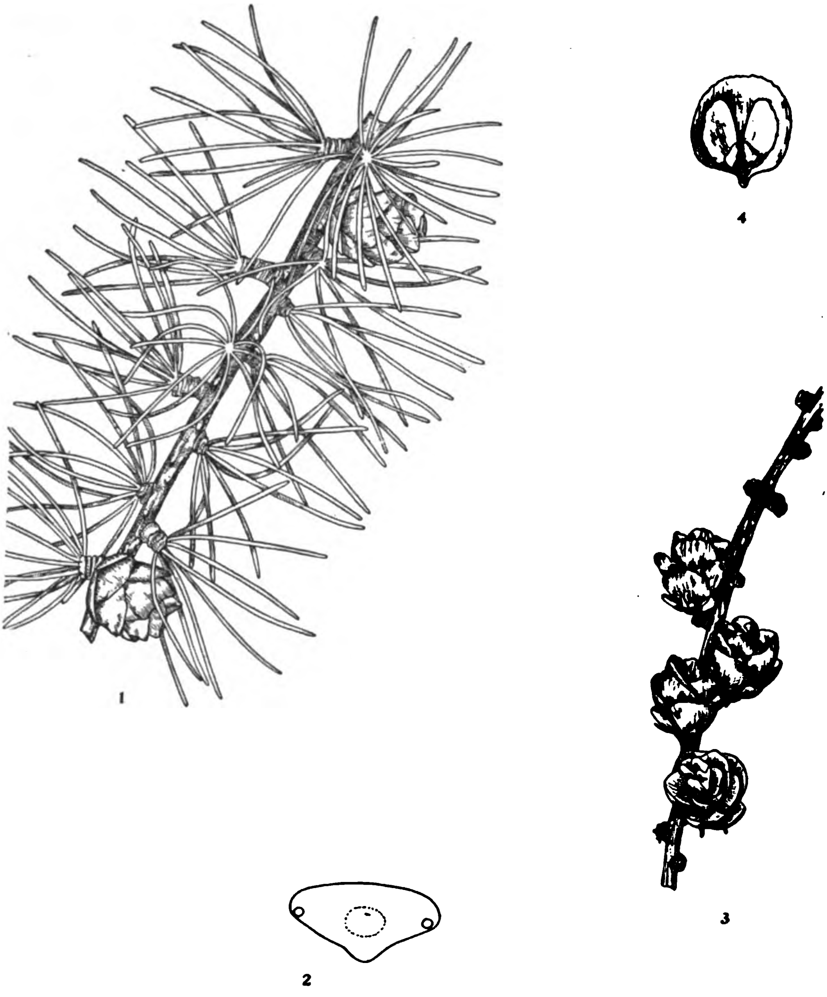
HABITAT.—Poor soils; sandy plains and dry woods.

NOTES.—The red pine makes a rapid growth on our better soils. It is difficult to transplant but should be used extensively.

The name "red pine" is appropriate both because of the pale red color of the heart wood and the distinctly reddish cast of the bark. This species does not grow in Norway or elsewhere in Europe, and it is said that it received the name from the town of Norway, Maine. The name "Norway pine" has so little fitness as applied to this tree, and evidently is so misleading that its use is to be discouraged.

The picturesqueness and individuality of the red pine commend it for wider use as an ornamental tree.

Tamarack



(Mich. Trees).

1. Autumn branchlet, with leaves and cones, x 1.
2. Cross-section of leaf, enlarged.
3. Fruiting branchlet in winter, x 1.
4. Cone-scale with seeds, x 2.

PINACEAE

Tamarack

Larix laricina (DuRoi) Koch [Larix americana Michx.]

HABIT.—A tree sometimes 80-100 feet high, with a trunk diameter of 1-2 feet; forming a broad, open, irregular crown of horizontal branches.

LEAVES.—Scattered singly along the leading shoots or clustered on the short lateral branchlets; linear, with blunt apex; rounded above, keeled beneath; about 1 inch long; bright green; sessile. Deciduous in early autumn.

FLOWERS.—May, with the leaves; monoecious; the staminate sessile, subglobose, yellow, composed of many short-stalked anthers spirally arranged about a central axis; the pistillate oblong, short-stalked, composed of orbicular, green scales (subtended by red bracts) spirally arranged about a central axis.

FRUIT.—Autumn of first season, but persistent on the tree for a year longer; ovoid, obtuse, light brown, short-stalked cones, ½-¾ inch long; seeds ⅛ inch long, with pale brown wings widest near the middle.

WINTER-BUDS.—Small, globose, lustrous, dark red.

BARK.—Twigs at first grayish, glaucous, later light orange-brown, and finally dark brown; red-brown and scaly on the trunk. Plate I.

WOOD.—Heavy, hard, very strong, coarse-grained, very durable, light brown, with thin, nearly white sapwood. Page 219.

DISTRIBUTION.—Common throughout Vermont, except in the lower Connecticut valley.

HABITAT.—Cold, deep swamps.

NOTES.—The tamarack becomes a picturesque tree in old age. It grows slowly in swamps, but rapidly on well-drained soils. It is our only cone-bearing tree which drops its leaves in the autumn. The tamarack is an attractive, conical tree, its graceful form and full clusters of slender, delicate leaves giving it a well-marked individuality. Its deep red, fleshy cones, which open in June, resemble flower clusters.

THE SPRUCES

Every Vermonter should know and appreciate the spruces for the mountain spruce and the sugar maple are our most characteristic trees. The forests of North America contain seven species of spruce, three of which occur in Vermont.[1]

The spruces are northern trees, and Vermont lies rather south of the belt of their most abundant growth in northeastern America. It is therefore our mountain sides and cool swamps which furnish conditions suitable for their best development.

The flowering cones are similar to those of the pine in general characters. The flowers appear in spring and the cones mature the following autumn, the seeds being shed during autumn or early winter.

Until recently botanists considered the two species here described as the red spruce and the black spruce to be simply varieties of one species, to which was given the common name of black spruce. In the lumber trade all three kinds are handled, without discrimination, as "spruce." As a matter of fact, the red spruce furnishes nearly all of the spruce lumber cut in Vermont. Spruce gum also comes chiefly from the red spruce, although it is formed by the other species.

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[1] *Introduced species.*—The Norway spruce (*Picea abies*) is commonly cultivated in Vermont dooryards, parks and cemeteries, and is superior to our native trees for such purposes. It is recognized easily by its more pendulous branches and very large slender cones, five to seven inches long.

The Colorado blue spruce (*P. pungens*) is occasionally planted. This is characterized by its beautiful glaucous-blue foliage. The cones are three to five inches long.

SUMMER AND WINTER KEY TO THE SPECIES OF PICEA

a. Leaves 1/8-5/8 inch long; twigs conspicuously pubescent.

  b. Leaves usually 1/8-3/8 inch long, typically blunt-pointed, dark blue-green; cones about 1 inch long, persistent on the branches for many years, their scales ragged-toothed; tree typical of swamps .... **P. mariana,** p. 43.

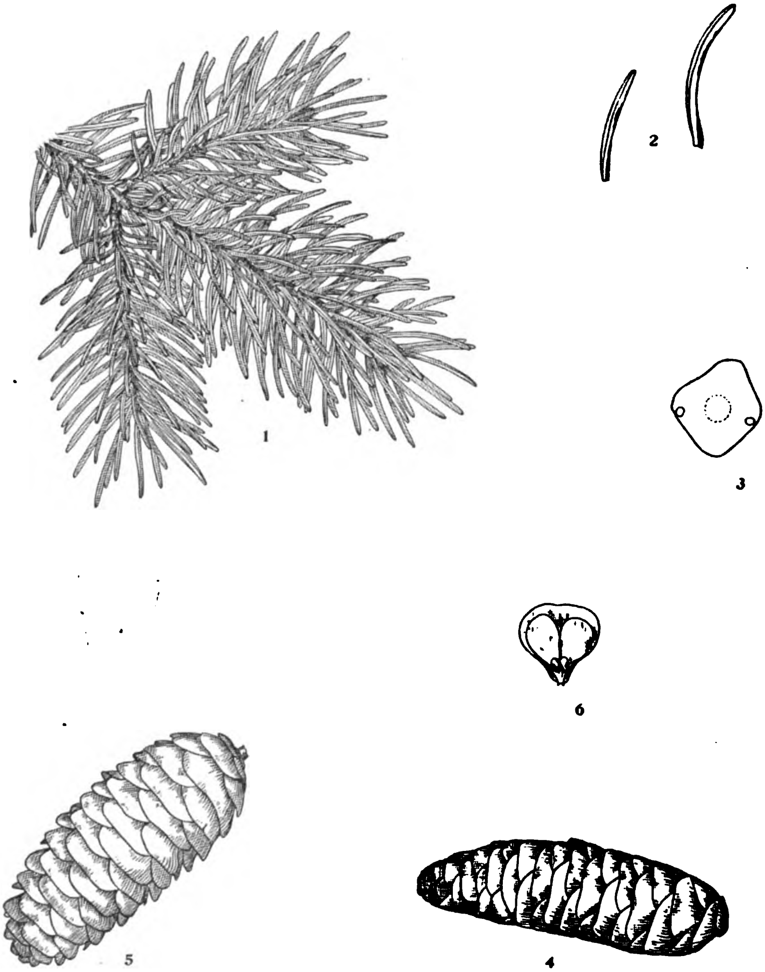
  bb. Leaves 3/8-5/8 inch long, typically sharp-pointed, dark yellow-green; cones 1¼-2 inches long, falling mostly during their first winter, their scales not ragged-toothed; tree typical of well-drained uplands and rocky slopes............ **P. rubra,** p. 41.

aa. Leaves 5/8-1 inch long; twigs not conspicuously pubescent, usually glabrous.

  b. Cones 1-2 inches long, maturing and falling in first season, their scales not toothed; leaves ill-scented when bruised, **P. canadensis,** p. 39.

  bb. Cones 3-6 inches long, maturing and falling in second season, their scales finely toothed; leaves not ill-scented when bruised, **P. abies,** p. 45.

White Spruce



(Mich. Trees).

1. Winter branchlet, x 1.
2. Leaves, x 1.
3. Cross-section of leaf, enlarged.
4. Unopened cone, x 1.
5. Partly opened cone, x 1.
6. Cone-scale with seeds, x 1.

PINACEAE

White Spruce

Picea canadensis (Mill.) BSP. [Picea alba Link]

HABIT.—A tree 70-100 feet high, with a trunk diameter of 1-3 feet; forming a rather broad, open, pyramidal crown.

LEAVES.—Spirally arranged, but crowded on the upper side of the branches by the twisting of those on the under side; awl-shaped, 4-sided, incurved; dark blue-green; about ¾ inch long; ill-scented when bruised. Persistent for several years.

FLOWERS.—May; monoecious; the staminate in oblong-cylindrical, long-stalked clusters, ½-¾ inch long, composed of many spirally arranged, red anthers; the pistillate in oblong-cylindrical clusters, composed of broad, reddish scales (subtended by orbicular bracts) spirally arranged upon a central axis.

FRUIT.—Autumn or early winter of first season, falling soon after discharging the seeds; pendent, slender, oblong-cylindrical, nearly sessile cones, 1-2 inches long; seeds about ⅛ inch long, with large wings oblique at the apex.

WINTER-BUDS.—Broadly ovoid, obtuse, light brown, ⅛-¼ inch long.

BARK.—Twigs smooth, gray-green, becoming orange-brown, finally dark gray-brown; thin, light gray-brown on the trunk, separating into thin, plate-like scales.

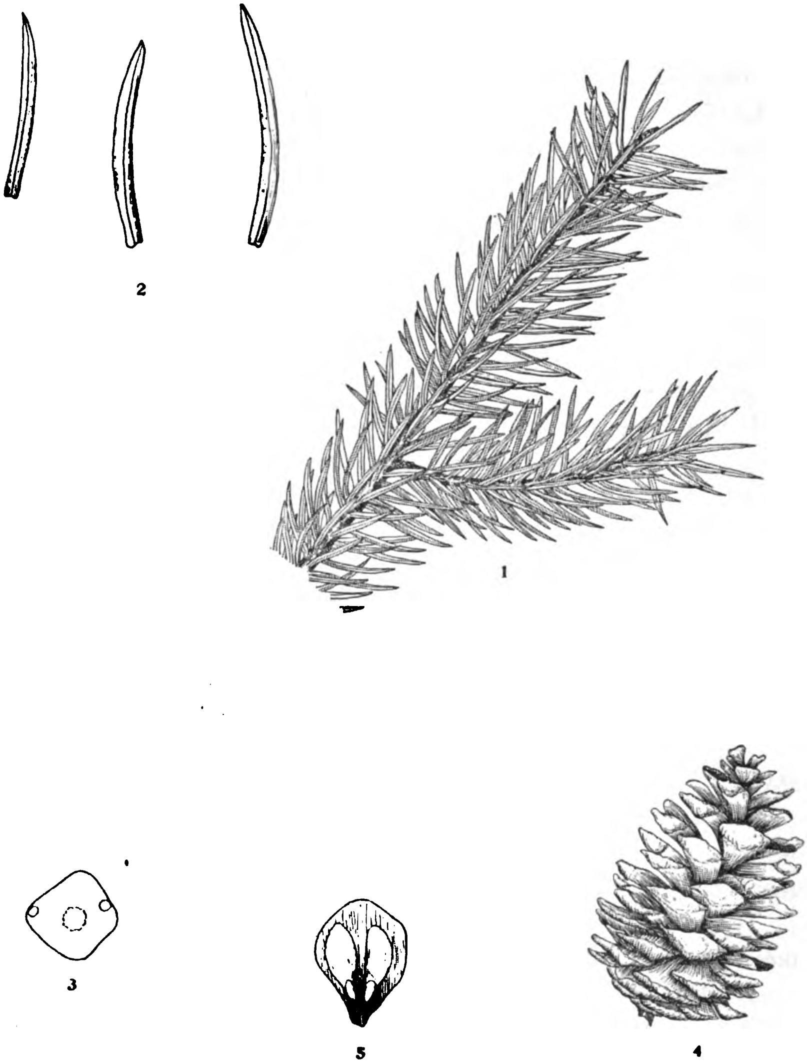
WOOD.—Light, soft, weak, straight-grained, light yellow, with sapwood of the same color.

DISTRIBUTION.—Common in the northeastern quarter of Vermont; also on some of the islands of Lake Champlain; has been reported from other isolated districts.

HABITAT.—Low, damp woods; banks of streams; borders of lakes; high, rocky or sandy slopes.

NOTES.—This is a northern tree which extends from Canada into northern Vermont. It occurs along the Connecticut river to the Fifteen Mile Falls (South Lunenburg), and on the eastern arm of the Y of the Green Mountains to the Montpelier and Wells River railroad, or perhaps a little farther south. It is common on some of the islands of Lake Champlain and is scattered through the forests of Essex county. The strong polecat odor of the young branches is characteristic and will aid in its recognition. Because of this odor it is sometimes called "skunk spruce." Lumbermen do not separate this from the other spruces and the tree is nearly equal in size to the red spruce.

Red Spruce



1. **Winter branchlet, x 1.**
2. **Leaves, x 2.**
3. **Cross-section of leaf, enlarged.**
4. **Opened cone, x 1.**
5. **Cone-scale with seeds, x 1.**

PINACEAE

Red Spruce

Picea rubra (DuRoi) Dietr. [Picea rubens Sarg.]

Habit.—A tree 50-80 feet high, with a trunk diameter of 1-3 feet; forming a narrow, conical crown of slender, spreading branches reaching nearly to the ground; when crowded, usually lacking branches for much of its length.

Leaves.—Spirally arranged, pointing outward in all directions; awl-shaped, 4-sided, mostly sharp or thickly taper-pointed, more or less incurved; slender; lustrous, dark yellow-green; 3/8-5/8 inch long. Persistent for several years.

Flowers.—May; monoecious; the staminate in ovoid clusters, about 1/2 inch long, composed of many spirally arranged, bright red anthers; the pistillate in oblong-cylindrical clusters, 3/4 inch long, composed of thin, rounded, purple scales (subtended by small, obovate bracts) spirally arranged upon a central axis.

Fruit.—Autumn of first season, falling mostly during their first winter; pendent, elongate-ovoid, short-stalked cones, 1 1/4-2 inches long; seeds about 1/8 inch long, dark brown, with short, broad wings.

Winter-buds.—Ovoid, acute, light red-brown, puberulous, about 3/16 inch long.

Bark.—Twigs at first greenish, with dense, whitish pubescence, becoming light brown and rusty-pubescent; thin, red-brown on the trunk, flaky with thin scales.

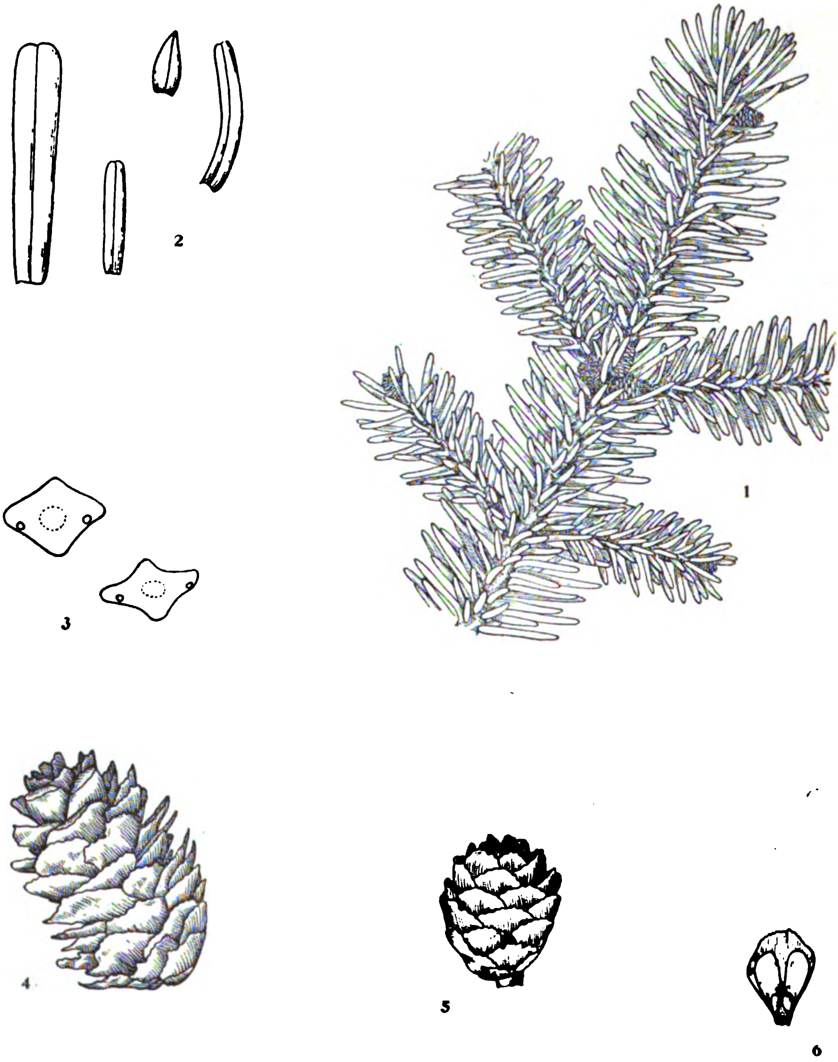
Wood.—Light, soft, weak, close-grained, pale and tinged with red, with thin, paler sapwood. Page 217.

Distribution.—Common throughout Vermont especially on the mountain slopes.

Habitat.—Well-drained uplands; rocky slopes with thin soil; sometimes extending down to the borders of swamps.

Notes.—This is the common spruce of our mountain forests, the vast green expanse of which suggested the names of both mountain range and State. It is not distinguished commonly from the preceding species and both are known as "black spruce." It attains a height of from seventy to one hundred feet and large logs may be three or more feet in diameter. When growing in open fields it often forms a conical head with the branches, especially of the younger trees, brushing the ground. It frequently is planted as an ornamental tree in Vermont, but its slower growth and less symmetrical form make it less desirable for this purpose than the native white spruce or Norway spruce.

Swamp Spruce. Black Spruce



(Mich. Trees).

1. **Winter branchlet, x 1.**
2. **Leaves, x 2.**
3. **Cross-sections of leaves, enlarged.**

4-5. Opened cones, x 1.

6. **Cone-scale with seeds, x 1.**

PINACEAE

Swamp Spruce. Black Spruce

Picea mariana (Mill.) BSP. [Picea nigra Link]

HABIT.—A small tree 20-50 feet high, with a trunk diameter of 6-12 inches; forming a narrow-based, conical, more or less irregular crown of short, slender, horizontal branches; often small and stunted.

LEAVES.—Spirally arranged, spreading in all directions; awl-shaped, 4-sided, blunt at the apex, more or less incurved; stiff; dark blue-green and glaucous; ⅛-⅜ inch long. Persistent for several years.

FLOWERS.—May; monoecious; the staminate in subglobose clusters, about ½ inch long, composed of many spirally arranged, dark red anthers; the pistillate in oblong-cylindrical clusters, composed of broad, purple scales (subtended by rounded, toothed, purple bracts) spirally arranged upon a central axis, about ½ inch long.

FRUIT.—Autumn of first season, but persistent on the branch for many years; pendent, ovoid, short-stalked cones, about 1 inch long; seeds about ⅛ inch long, with pale brown wings ½ inch long.

WINTER-BUDS.—Ovoid, acute, light red-brown, puberulous, ⅛ inch long.

BARK.—Twigs at first green and rusty-pubescent, becoming dull red-brown and rusty-pubescent; thin, gray-brown on the trunk, separating into thin, appressed scales.

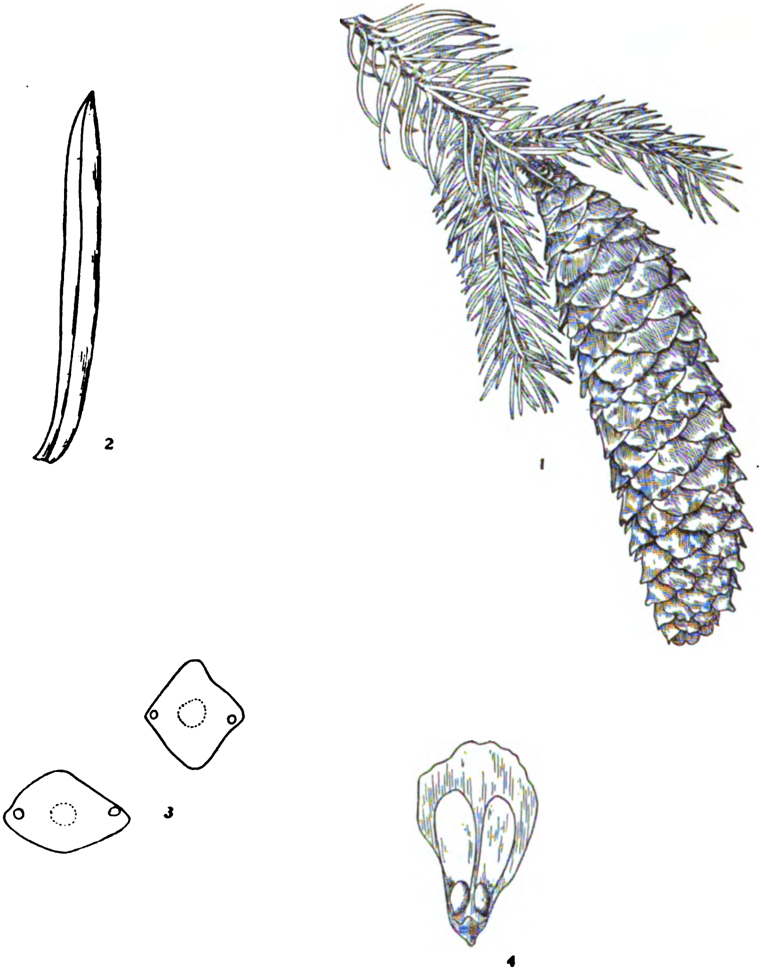
WOOD.—Light, soft, weak, pale yellow-white, with thin, pure white sapwood.

DISTRIBUTION.—This is the common spruce of the sphagnum (peat moss) swamps of the Champlain valley. It is also common in Essex and Franklin counties and probably occurs similarly in the other parts of Vermont, especially in peat bogs, but the distribution is not well known because of its confusion until recently with the red spruce.

HABITAT.—Cold, sphagnous bogs and swamps; shores of lakes.

NOTES.—The black spruce is short-lived. It is undesirable for ornamental planting, as the lower branches die early, making an unattractive evergreen. A small, semi-prostrate, sterile form, *Picea mariana, forma semiprostrata,* occurs on the summit of Mt. Mansfield.

Norway Spruce



(Mich. Trees).

1. Branchlet with partly opened cone, x½.
2. Leaf, x 3.
3. Cross-sections of leaves, enlarged.
4. Cone-scale with seeds, x 1.

PINACEAE

Norway Spruce

Picea abies (L.) Karst. [Picea excelsa Link]

HABIT.—A tree 50-70 feet high, with a trunk diameter of 1-3 feet; forming a dense, conical, spire-topped crown of numerous, drooping branches which persist nearly to the ground.

LEAVES.—Spirally arranged along the twig; crowded; ¾-1 inch long; rigid, curved, acute; lustrous, dark green. Persistent 5-7 years.

FLOWERS.—May; monoecious; the staminate in ovoid to subglobose clusters, long-stalked, reddish to yellowish, ¾-1 inch long; the pistillate in cylindrical clusters, sessile, erect, 1½-2 inches long.

FRUIT.—Autumn of second season; sessile, cylindrical cones 3-6 inches long, pendent from the tips of the uppermost branches; sterile scales very short, toothed; seeds red-brown, rough, ⅛ inch long, with long wings.

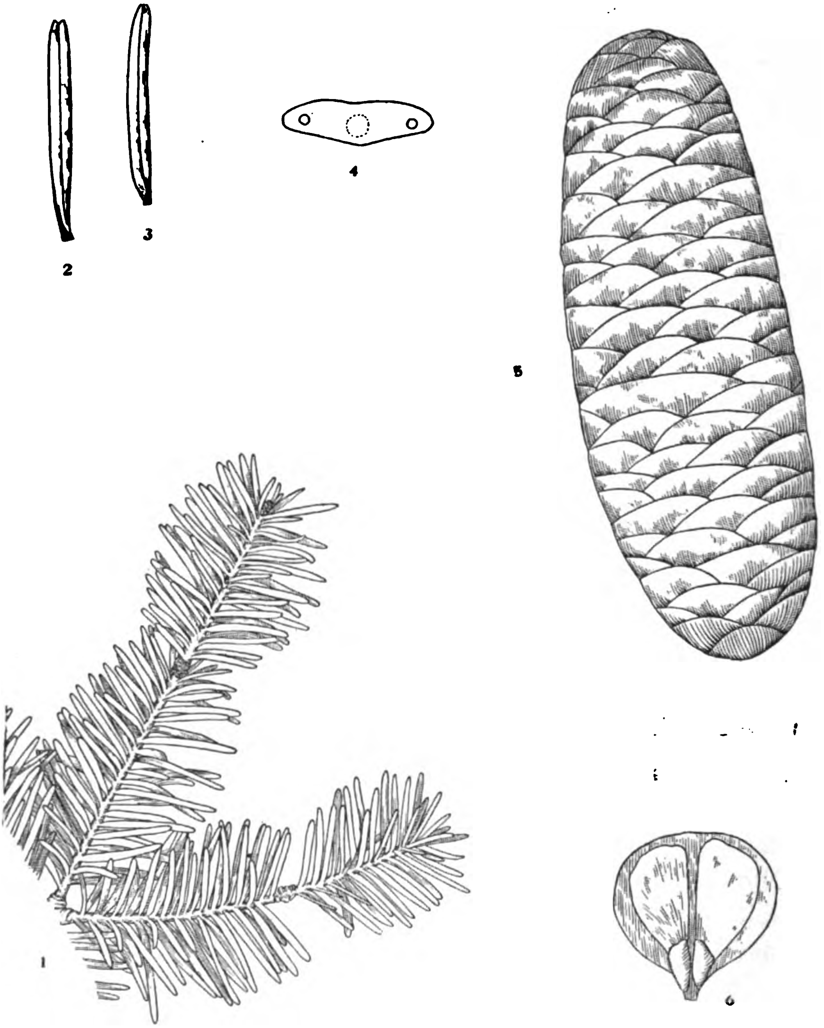
WINTER-BUDS.—Ovoid, acute, red-brown, not resinous, about ⅜ inch long.

BARK.—Twigs red- or orange-brown, smooth or corrugated; becoming thin and gray-brown on old trunks, slightly fissured, scaly.

WOOD.—Light, strong, tough, elastic, soft, fined-grained, white, with thick, indistinguishable sapwood.

NOTES.—This tree is native throughout northern Europe and Asia where it grows to a height of 120 to 150 feet. It is perfectly hardy here and is the common spruce found in dooryards throughout Vermont. As it adapts itself to a variety of soils and climates and grows rapidly, it is especially desirable for ornamental planting, hedges and windbreaks. One of the best known plantations of this spruce is a small area on the Billings estate at Woodstock, which was planted nearly 40 years ago.

Balsam Fir



(Mich. Trees).

1. Winter branchlet, x 1.
2-3. Leaves, x 2.
4. Cross-section of leaf, enlarged.
5. Unopened cone, x 1.
6. Cone-scale with seeds, x 1.

PINACEAE

Balsam Fir

Abies balsamea (L.) Mill.

HABIT.—A slender tree 40-60 feet high, with a trunk diameter of 12-18 inches; branches in whorls of 4-6, forming a symmetrical, open crown widest at the base and tapering regularly upward.

LEAVES.—Scattered, spirally arranged in rows, on young trees at right angles to the branch, on old trees covering the upper side of the branch; narrowly linear, with apex acute or rounded; ½-1¼ inches long; lustrous, dark green above, pale beneath; sessile; aromatic. Persistent 8-10 years.

FLOWERS.—May; monoecious; the staminate oblong-cylindrical, yellow, ¼ inch long, composed of yellow anthers (subtended by scales) spirally arranged upon a central axis; the pistillate oblong-cylindrical, 1 inch long, composed of orbicular, purple scales (subtended by yellow-green bracts) spirally arranged upon a central axis.

FRUIT.—Autumn of first season; oblong-cylindrical, erect, puberulous, dark purple cones, 2-4 inches long, about 1 inch thick; seeds ¼ inch long, shorter than their light brown wings.

WINTER-BUDS.—Globose, orange-green, resinous, ⅛-¼ inch in diameter.

BARK.—Twigs at first grayish and pubescent, becoming gray-brown and smooth; thin and smooth on young trunks, pale gray-brown and marked by swollen resin chambers; red-brown on old trunks and somewhat roughened by small, scaly plates.

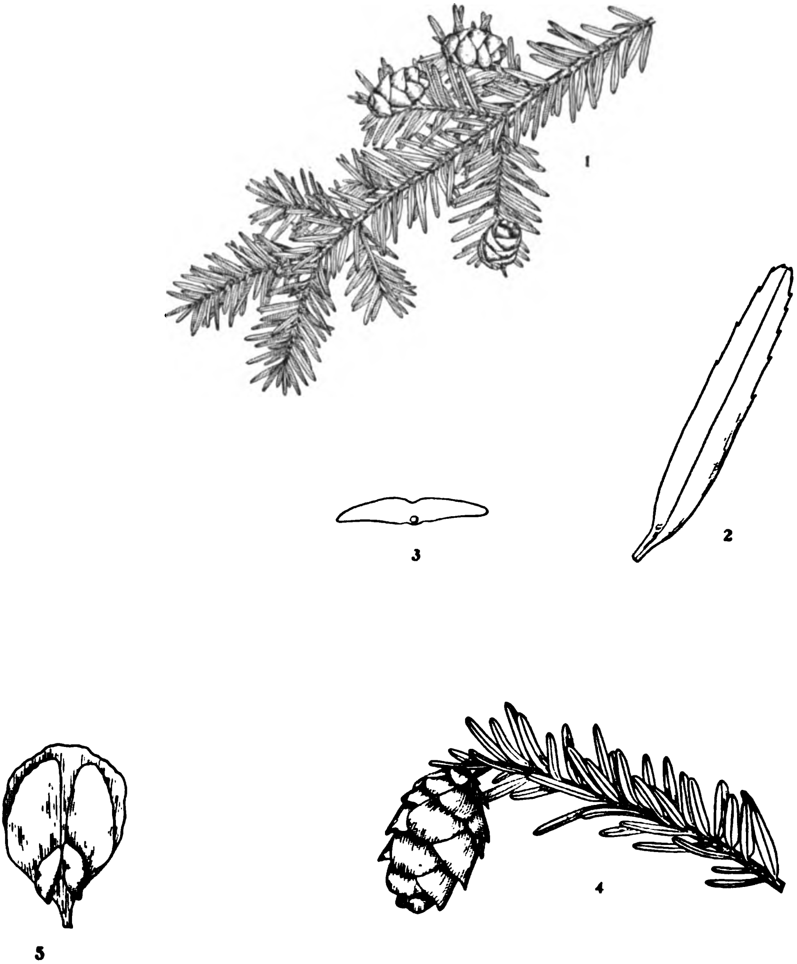
WOOD.—Very light, soft, weak, coarse-grained, perishable, pale brown, with thick, lighter colored sapwood. Page 221.

DISTRIBUTION.—Common in the mountain forests throughout Vermont, ascending to the summits of Mt. Mansfield and Camel's Hump, although there it is reduced to a low, scrubby growth; not reported in the Connecticut valley south of Hartland.

HABITAT.—Cold, wet woods and swamps, in the higher altitudes.

NOTES.—The balsam fir, more familiarly known as the fir tree or balsam, is a slender, graceful tree when growing in open ground. It bears a general resemblance to the spruces, but is distinguished easily from them on close observation. The leaves are flat, gray on the under side, with a conspicuous green midrib. The erect cones, 2 to 4 inches long, stand like Christmas candles on the upper branches. There is a characteristic fragrance from the bruised leaves and they are much prized for making pillows.

Hemlock



(Mich. Trees).

1. Fruiting branch viewed from beneath, x ½.
2. Leaf, x 3.
3. Cross-section of leaf, enlarged.
4. Branchlet with partly opened cone, x 1.
5. Cone-scale with seeds, x 3.

PINACEAE

Hemlock

Tsuga canadensis (L.) Carr.

HABIT.—A large tree 60-80 feet high, with a trunk 2-4 feet in diameter; forming a rather broad, open, somewhat irregular-pyramidal crown of slender, horizontal branches.

LEAVES.—Spirally arranged around the branch, but appearing 2-ranked by the twisting of their petioles; linear, flat, rounded at the apex; about ½ inch long; dark yellow-green and shining above, hoary beneath; short-petioled. Persistent about 3 years.

FLOWERS.—May; monoecious; the staminate axillary, short-stalked, light yellow, about ⅜ inch long, composed of subglobose clusters of stamens; the pistillate terminal, oblong, pale green, ⅛ inch long, the scales short, pinkish.

FRUIT.—Autumn of first season, gradually losing their seeds during the winter and falling the next spring; oblong-ovoid, acute, short-stalked, red-brown cones, about ¾ inch long; seeds ⅛ inch long, with wings about twice as long.

WINTER-BUDS.—Ovoid, obtuse, red-brown, slightly puberulous, 1/16 inch long.

BARK.—Twigs at first pale brown and pubescent, becoming glabrous, gray-brown; thick, red-brown or gray on the trunk, deeply divided into narrow, rounded, scaly ridges. Plate II.

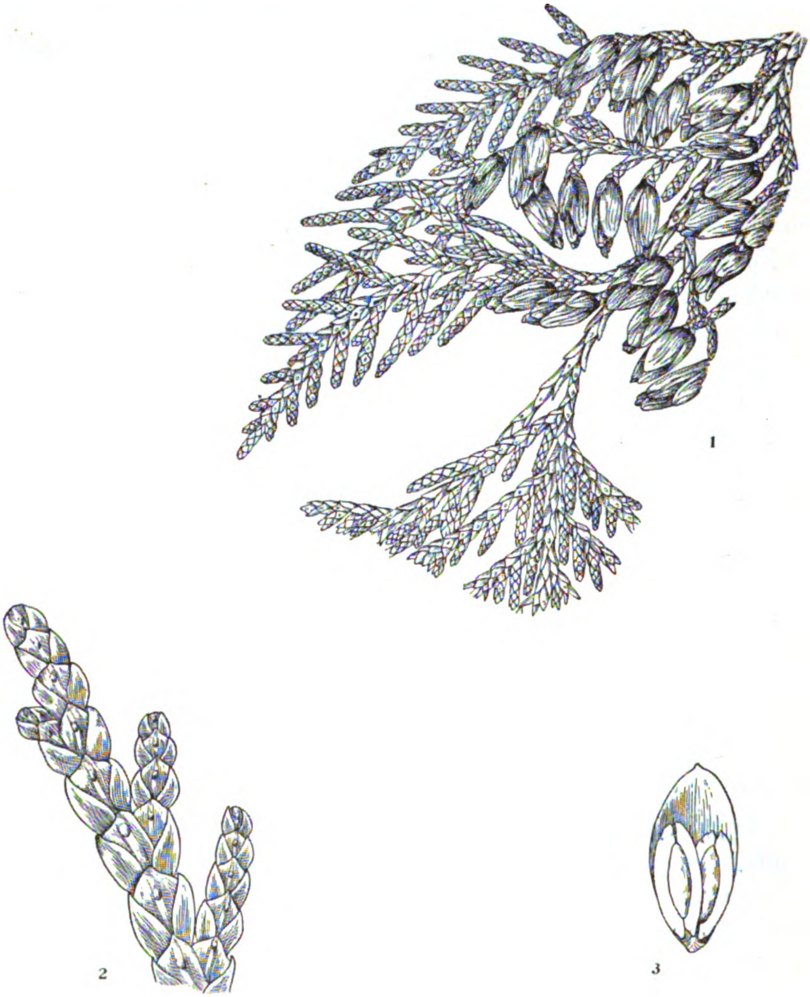
WOOD.—Light, soft, weak, brittle, coarse, and crooked-grained, not durable, ill-smelling, light red-brown, with thin, darker colored sapwood. Page 219.

DISTRIBUTION.—Common throughout Vermont, especially in the mountain forests.

HABITAT.—Rocky woods and hillsides; borders of swamps; mountain forests; low river-banks.

NOTES.—The hemlock is one of the most graceful of our evergreen trees. It may be met with almost everywhere from the low river-banks and swamps to the rocky hillsides and mountain forests. In distinguishing the hemlock from the spruce and balsam fir, one should notice the flat, petioled leaves arranged in a flattened spray with a row on the upper side lying close to the stem. The small ellipsoidal cones, scarcely more than three-fourths of an inch long, mature in the autumn and shed their seeds during the winter.

Arbor Vitae. White Cedar



(Mich. Trees).

1. Fruiting branchlet, x 1.
2. Tip of branchlet, enlarged.
3. Cone-scale with seeds, x 3.

PINACEAE

Arbor Vitae. White Cedar

Thuja occidentalis L.

HABIT.—A tree 40-50 feet high, with a short, often buttressed trunk 1-2 feet in diameter, often divided into 2-3 secondary stems; forming a rather dense, wide-based, pyramidal crown.

LEAVES.—Opposite, 4-ranked, scale-like, appressed; ovate, obtuse or pointed, keeled in the side pairs, flat in the others; 1/8-1/4 inch long; yellow-green, often becoming brown in winter; strongly aromatic when crushed. Persistent 1-2 years.

FLOWERS.—April-May; usually monoecious; the staminate minute, globose, yellow, composed of 4-6 stamens arranged oppositely on a short axis; the pistillate small, oblong, reddish, composed of 8-12 scales arranged oppositely on a short axis.

FRUIT.—Early autumn of first season, but persistent on the branch through the winter; erect, short-stalked, oblong-ovoid, pale brown cones, about 1/2 inch long, composed of 8-12 loose scales; seeds 1/8 inch long, ovate, acute, winged.

WINTER-BUDS.—Naked, minute.

BARK.—Twigs, yellow-green, becoming light red, finally smooth, lustrous, dark orange-brown; thin, light red-brown on the trunk, slightly furrowed or deciduous in ragged strips.

WOOD.—Light, soft, brittle, rather coarse-grained, durable, fragrant, pale yellow-brown, with thin, whitish sapwood. Page 221.

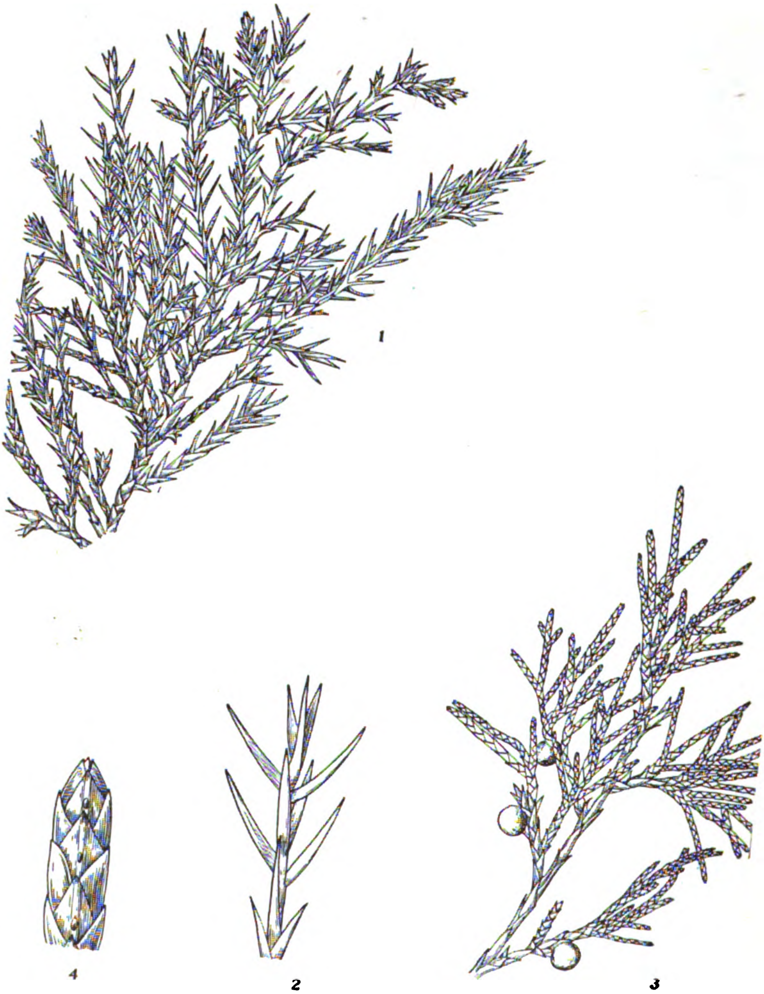
DISTRIBUTION.—Common in northern and central Vermont, and as far south as Woodstock and Hartland in eastern Vermont, up to 1,000 feet altitude.

HABITAT.—Swamps and along river-banks; rocky slopes; cool, moist hillsides.

NOTES.—This tree is known popularly in Vermont as the white cedar and is recognized easily by its striking pyramidal habit of growth and, upon closer examination, by its small scale-like leaves, in four rows but so flattened on the branchlets as to form fan-like sprays.

The straight slender trunks of this species are of especial value for posts and telegraph poles. Few timbers better withstand decay in the soil, fence posts sometimes lasting thirty or forty years. It is planted commonly for hedges and other ornamental purposes.

Red Cedar



(Mich. Trees).

1. Branchlet with awl-shaped leaves, x 1.
2. Tip of branchlet, showing awl-shaped leaves, enlarged.
3. Fruiting branchlet with scale-like leaves, x 1.
4. Tip of branchlet, showing scale-like leaves, enlarged.

PINACEAE

Red Cedar

Juniperus virginiana L.

HABIT.—A medium-sized tree 30-40 feet high, with a trunk diameter of a foot; forming an irregular, pyramidal or rounded crown.

LEAVES.—Opposite, of two kinds: (1) sessile, scale-like, closely appressed, overlapping, 4-ranked, ovate, acute, 1/16 inch long, (2) sessile, awl-shaped, loosely-arranged, 1/4-1/2 inch long. Persistent 5-6 years.

FLOWERS.—May; usually dioecious; minute; the staminate oblong-ovoid, composed of 4-6 shield-like scales, each bearing 4-5 yellow, globose pollen sacs; the pistillate ovoid, composed of about 3 pairs of fleshy, bluish scales, united at the base and bearing 2 ovules.

FRUIT.—Autumn of first or second season; subglobose, berry-like strobile, about 1/4 inch in diameter, dark blue and glaucous; flesh sweet and resinous; seeds 2-3.

WINTER-BUDS.—Naked, minute.

BARK.—Twigs greenish to red-brown and smooth; thin, light red-brown on the trunk, exfoliating lengthwise into long, narrow, persistent strips, exposing the smooth, brown inner bark.

WOOD.—Light, soft, close-grained, brittle, weak, durable, very fragrant, dull red, with thin, whitish sapwood.

DISTRIBUTION.—Common in lower altitudes of western Vermont, less so in the mountain range of southwestern Vermont; more or less common in the Connecticut valley as far north as Fairlee.

HABITAT.—Dry, rocky hills; also borders of lakes and streams, peaty swamps.

NOTES.—Three kinds of juniper are found in Vermont, but this one, commonly known as "red cedar," is the only one which has the size and habit of a tree. It somewhat resembles the arbor vitæ, from which it may be distinguished at a distance by its less symmetrical form and darker foliage. Closer inspection shows that its scale-like leaves have little tendency to the arrangement in a plane which is characteristic of the arbor vitæ. The fruit also is distinguishable readily from that of the other cone-bearing trees. It consists of thick, fleshy scales which coalesce to form a structure looking more like a small berry than a cone, green in midsummer, becoming bluish at maturity in the autumn. The leaves of young shoots are longer than those on the older branches, with needle-like points. The heartwood of this tree is soft, red and fragrant, and that obtained from the southern states is largely used in the manufacture of pencils.

SALICACEAE—WILLOWS

The classification of the willows is a task for the specialist, even when leaves and both staminate and pistillate flowers are obtainable. For this reason the usual summer and winter keys have been omitted.

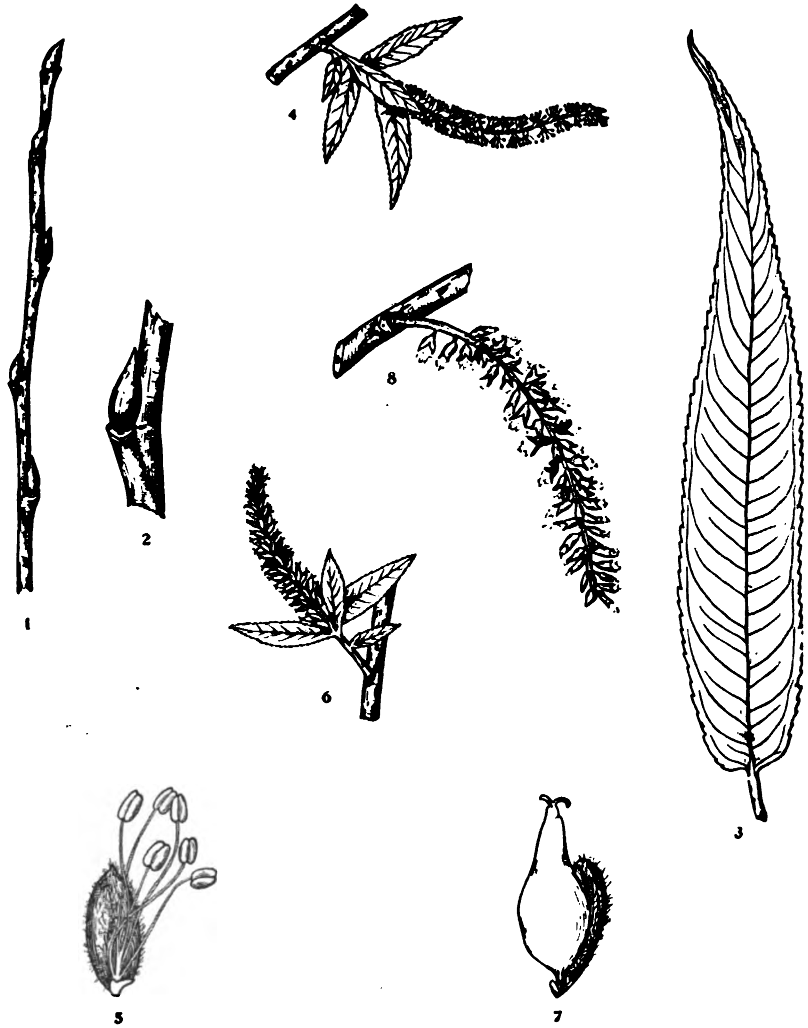
SALICACEAE

THE WILLOWS

The genus *Salix* is represented in Vermont by 25 distinct species or varieties and by a number of hybrids. The majority of these are shrubs, only a few becoming truly arborescent. Because of the similarity of their botanical characters, the frequency with which they hybridize, and the facility with which they respond to their environment, only an expert is competent to identify the species so abundant along our water courses and on the banks of our lakes and swamps. The scope of this work necessarily being limited, it has been deemed best to describe but one of our native willows and one of our foreign neighbors which is planted frequently.

Willows are introduced commonly as shade trees because they are propagated so easily by cuttings. Care should be taken, however, to select the stamen-bearing trees, both because these are more ornamental when in flower and because they do not produce the downy fruit which often is disagreeable when willows are growing near houses.

Black Willow



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Staminate flowering branchlet, x 1.
5. Staminate flower, enlarged.
6. Pistillate flowering branchlets, x 1.
7. Pistillate flower, enlarged.
8. Fruiting branchlet, x 1.

SALICACEAE

Crack Willow

Salix fragilis L.

HABIT.—A tree 50-60 feet high, with a short, stout trunk 3-4 feet in diameter; stout, spreading branches form a broad, open crown.

LEAVES.—Alternate, simple, 3-6 inches long, ½-1½ inches broad; lanceolate, long-pointed; finely glandular-serrate; thin and firm; lustrous, dark green above, paler beneath, glabrous both sides; petioles short, stout, with 2 glands at the junction of blade and petiole.

FLOWERS.—May, with the leaves; dioecious; borne in slender, pubescent catkins 1-3 inches long; calyx 0; corolla 0; scales blunt, somewhat pubescent; stamens usually 2; ovary abortive, with stigmas nearly sessile. Staminate trees rare.

FRUIT.—May-June; 1-celled, long-conical, short-stalked capsule, about ¼ inch long, containing many minute seeds which are furnished with long, silky, white hairs.

WINTER-BUDS.—Terminal bud absent; lateral buds long-conical, pointed, glabrous, bright red-brown, about ¼ inch long.

BARK.—Twigs pubescent, yellow-green, often reddish, becoming glabrous, lustrous, brown; thick, gray on the trunk, smooth in young trees, very rough, irregularly scaly-ridged in old trees.

WOOD.—Light, soft, tough, close-grained, red-brown, with thick, whitish sapwood.

NOTES.—This willow is a native of Europe and Asia, where it is a valuable timber tree. It is commonly cultivated and frequently escapes. The crack willow is hardy throughout Vermont, of very rapid growth, and thrives in rich, damp soil. The twigs are very brittle at the base and are broken easily by the wind, hence the name "crack willow."

THE POPLARS

The genus *Populus* belongs to the willow family and resemble the willows, especially in flower and fruit characters. The nodding, worm-like, staminate and pistillate catkins are borne upon different trees, and opening before the leaves, are conspicuous in early spring. The poplars are distributed quite widely, extending from the Arctic Circle to Mexico and from the Atlantic to the Pacific.

The wood of poplars is very soft and light and especially liable to warp, but is cheap and useful for making toys, boxes and smaller furniture. Much of it now goes to the pulp mills.

SUMMER KEY TO THE SPECIES OF POPULUS

a. Leaf-petioles essentially terete.
  b. Petioles and lower sides of leaves pubescent; leaves heart-shaped ....**P. candicans,** p. 71.
  bb. Petioles and lower sides of leaves glabrous; leaves ovate-lanceolate ....**P. balsamifera,** p. 69.
aa. Leaf-petioles strongly flattened.
  b. Petioles and lower sides of leaves tomentose; twigs pubescent, **P. alba,** p. 63.
  bb. Petioles and lower sides of leaves glabrous; twigs glabrous.
    c. Leaves distinctly deltoid in shape.
      d. Leaves broader than they are long, abruptly acuminate at the apex; marginal teeth not conspicuously incurved; branches erect and more or less appressed to the main stem, forming a narrow, spire-like crown.**P. nigra italica,** p. 75.
      dd. Leaves longer than they are broad, more or less taper-pointed at the apex; marginal teeth rather conspicuously incurved; branches spreading, forming a broad crown. **P. deltoides,** p. 73.
    cc. Leaves ovate to nearly orbicular in shape.
      d. Margin of leaves coarsely sinuate-toothed; leaves 3-5 inches long ....**P. grandidentata,** p. 67.
      dd. Margin of leaves finely serrate; leaves less than 3 inches long ....**P. tremuloides,** p. 65.

WINTER KEY TO THE SPECIES OF POPULUS

a. Branches erect, more or less appressed to the main stem, forming a narrow, spire-like crown .... **P. nigra italica,** p. 75.

aa. Branches spreading, forming a broad crown.

- *b.* Terminal buds ⅛-¼ inch long, not resinous.
    - *c.* Buds and twigs more or less conspicuously white-downy; twigs green .... **P. alba,** p. 63.
    - *cc.* Buds and twigs not conspicuously white-downy; twigs usually red-brown.
        - *d.* Terminal buds about ⅛ inch long, puberulous, dusty-looking; lateral buds widely divergent; twigs rather coarse .... **P. grandidentata,** p. 67.
        - *dd.* Terminal buds about ¼ inch long, glabrous, lustrous; lateral buds more or less appressed; twigs rather slender, **P. tremuloides,** p. 65.
- *bb.* Terminal buds ½-1 inch long, sticky-resinous.
    - *c.* Terminal buds about ½ inch long; buds not fragrant; twigs usually yellow, more or less strongly angled, **P. deltoides,** p. 73.
    - *cc.* Terminal buds nearly 1 inch long; buds fragrant; twigs usually red-brown and seldom strongly angled, **P. balsamifera,**[1] p. 69. **P. candicans,**[1] p. 71.

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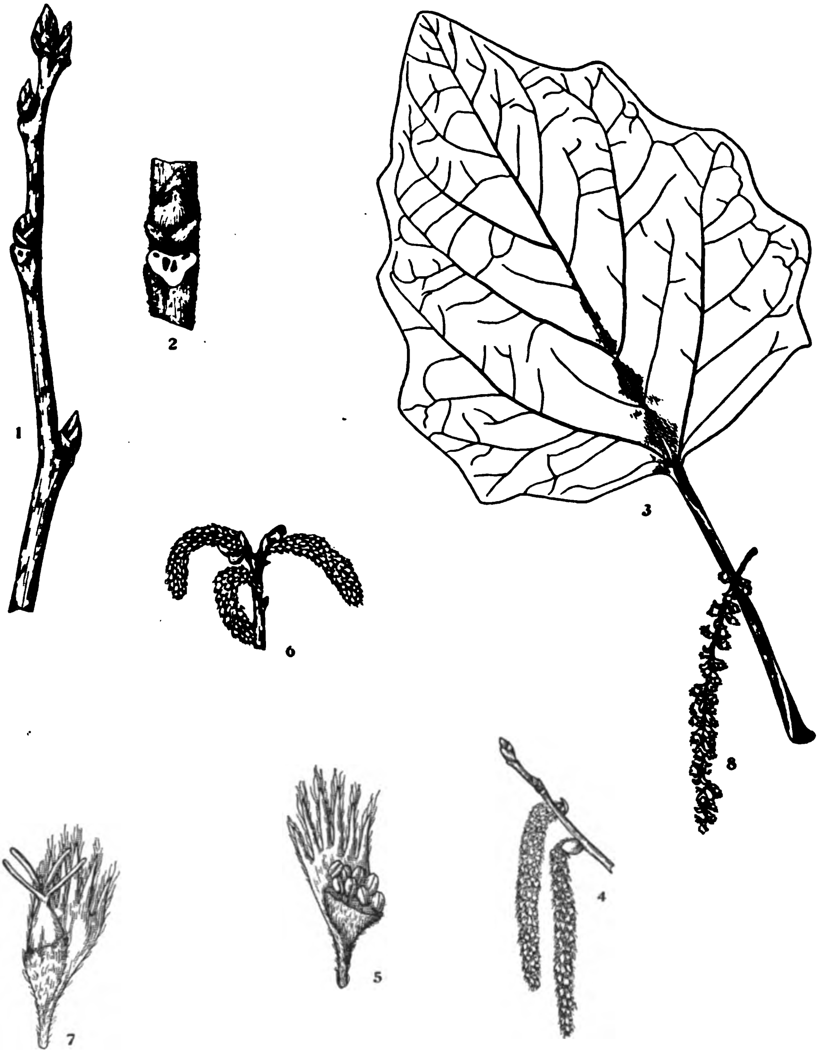
[1] It is difficult to distinguish between these species in the absence of summer characters. If leaves can be found on or beneath a tree which is sufficiently segregated from similar trees as to avoid any chance for error, the summer key on the opposite page may be used.

White Poplar. Silver-leaved Poplar



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 2.
4. Staminate flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flowering branchlet, x ½.
7. Pistillate flower, enlarged.
8. Fruit, x ½.

SALICACEAE

White Poplar. Silver-leaved Poplar

Populus alba L.

HABIT.—A large tree 50-75 feet high, with a trunk diameter of 2-4 feet, forming a large, spreading, rounded or irregular crown of large, crooked branches and sparse, stout branchlets.

LEAVES.—Alternate, simple, 2-4 inches long and almost as broad; broadly ovate to suborbicular; irregularly toothed, sinuate, or sometimes 3-5-lobed; glabrous, dark green above, white-tomentose to glabrous beneath; petioles long, slender, flattened, tomentose.

FLOWERS.—April-May, before the leaves; dioecious; the staminate catkins thick, cylindrical, 2-4 inches long; the pistillate catkins slender, 1-2 inches long; calyx 0; corolla 0; stamens 6-16, with purple anthers; stigmas 2, yellow.

FRUIT.—May-June; ovoid, 2-valved capsules, 1/8-1/4 inch long, borne in drooping catkins 2-4 inches long; seeds light brown, surrounded by long, white hairs.

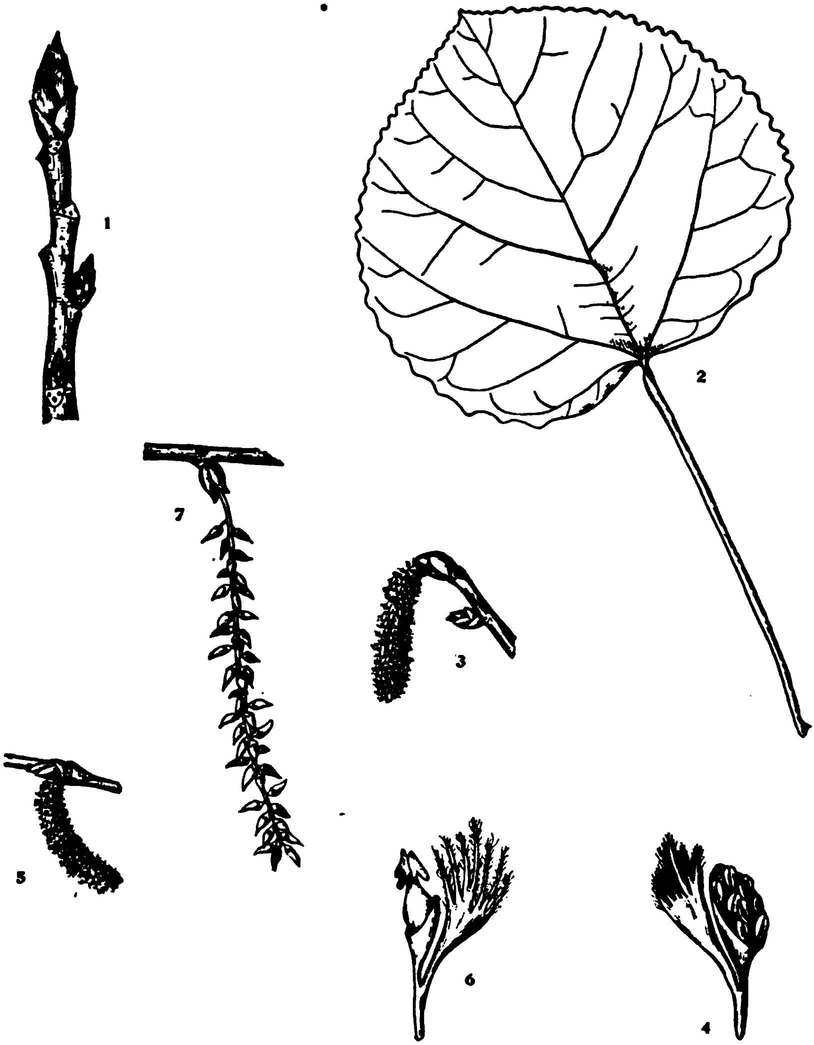
WINTER-BUDS.—Ovoid, pointed, not viscid, downy, about 1/4 inch long.

BARK.—Twigs greenish, covered with a white down, becoming greenish gray and marked with darker blotches; dark gray and fissured at the base of old trunks.

WOOD.—Light, soft, weak, difficult to split, reddish yellow, with thick, whitish sapwood.

NOTES.—The white poplar is a native of Europe and Asia. It is hardy in Vermont, and is cultivated frequently, occasionally becoming an escape. It grows rapidly in good soils but thrives also in poor soils and in exposed situations. The deep roots produce numerous suckers for a considerable distance from the tree.

American Aspen. Trembling Poplar. Popple



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x 1.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

SALICACEAE

American Aspen. Trembling Poplar. Popple

Populus tremuloides Michx.

HABIT.—A small, slender tree generally 35-45 feet high, with a trunk diameter of 8-15 inches; forming a loose, rounded crown of slender branches.

LEAVES.—Alternate, simple, 1½-2½ inches long and broad; broadly ovate to suborbicular; finely serrate; thin and firm; lustrous, dark green above, dull and pale beneath; petioles slender, laterally compressed. Tremulous with the slightest breeze.

FLOWERS.—April, before the leaves; dioecious; the staminate catkins 1½-3 inches long, the pistillate at first about the same length, gradually elongating; calyx 0; corolla 0; stamens 6-12; stigmas 2, 2-lobed, red.

FRUIT.—May-June; 2-valved, oblong-cylindrical, short-pedicelled capsules ¼ inch long; seeds light brown, white-hairy.

WINTER-BUDS.—Terminal bud about ¼ inch long, narrow-conical. acute, red-brown, lustrous; lateral buds often appressed.

BARK.—Twigs very lustrous, red-brown, becoming grayish and roughened by the elevated leaf-scars; thin, yellowish or greenish and smooth on the trunk, often roughened with darker, horizontal bands or wart-like excrescences, becoming thick and fissured, almost black at the base of old trunks.

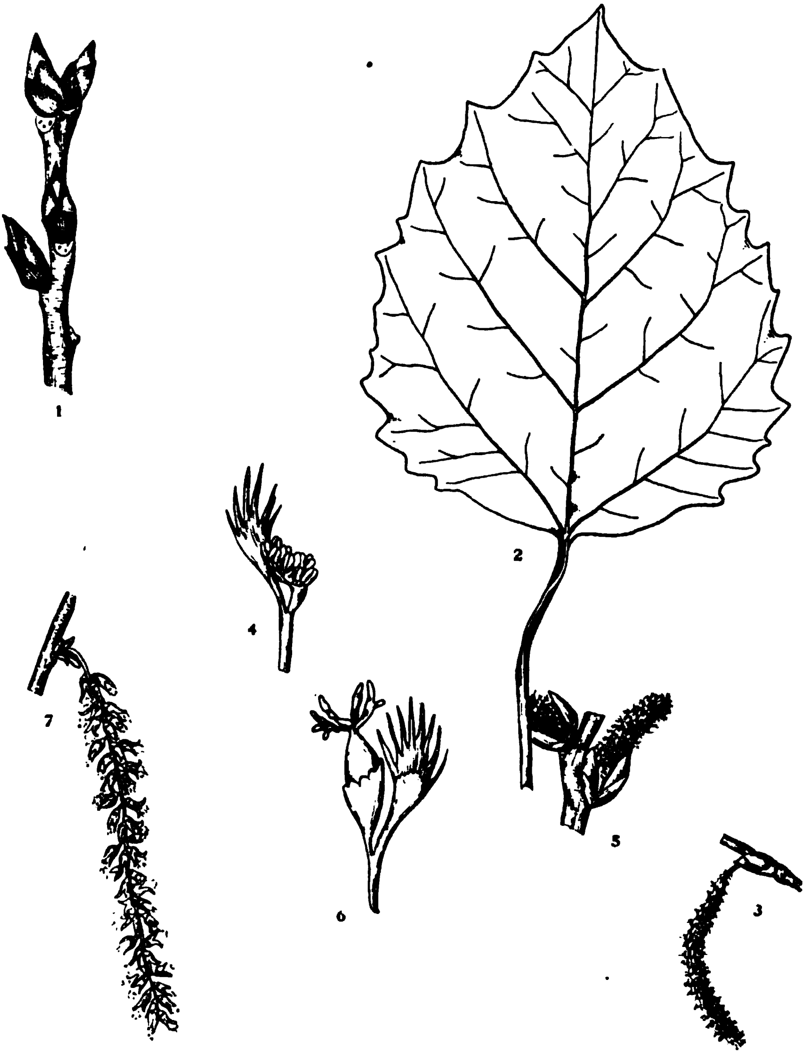
WOOD.—Light, soft, weak, close-grained, not durable, light brown, with thin, whitish sapwood. Page 229.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Prefers moist, sandy soil and gravelly hillsides.

NOTES.—The most careless observer cannot have failed to notice the leaves of the aspen continually trembling on the quietest summer day. This tremulousness, indeed, has given name to the species. The reason for it, as may be seen readily by examination of any leaf, lies in the decidedly flattened structure of the leaf-stem or petiole. The slender drooping catkins appear in early spring and the downy fruits ripen in the latter part of May. The American aspen grows to a medium size, and is the most widely distributed tree in North America, extending from Labrador to Alaska, from Lower California to the Atlantic coast.

Large-toothed Aspen



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x 1.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

SALICACEAE

Large-toothed Aspen

Populus grandidentata Michx.

HABIT.—A medium-sized tree 30-50 feet high, with a slender trunk 12-20 inches in diameter; forming a loose, oval or rounded crown of slender, spreading branches and coarse spray.

LEAVES.—Alternate, simple, 3-5 inches long, two-thirds as broad; orbicular-ovate; coarsely and irregularly sinuate-toothed; thin and firm; dark green above, paler beneath, glabrous both sides; petioles long, slender, laterally compressed.

FLOWERS.—April-May, before the leaves; dioecious; the staminate in short-stalked catkins 1-3 inches long; the pistillate in loose-flowered, long-stalked catkins at first about the same length, but gradually elongating; calyx 0; corolla 0; stamens 6-12, with red anthers; stigmas 2, 2-lobed, red.

FRUIT.—May-June; 2-valved, conical, acute, hairy capsules ⅛ inch long, borne in drooping catkins 4-6 inches long; seeds minute, dark brown, hairy.

WINTER-BUDS.—Terminal bud ⅛ inch long, ovoid to conical, acute, light chestnut, puberulous, dusty-looking.

BARK.—Twigs greenish gray and at first hoary-tomentose, becoming lustrous, orange or red-brown and finally greenish gray; thick, dark red-brown or blackish at the base of old trunks, irregularly fissured, with broad, flat ridges.

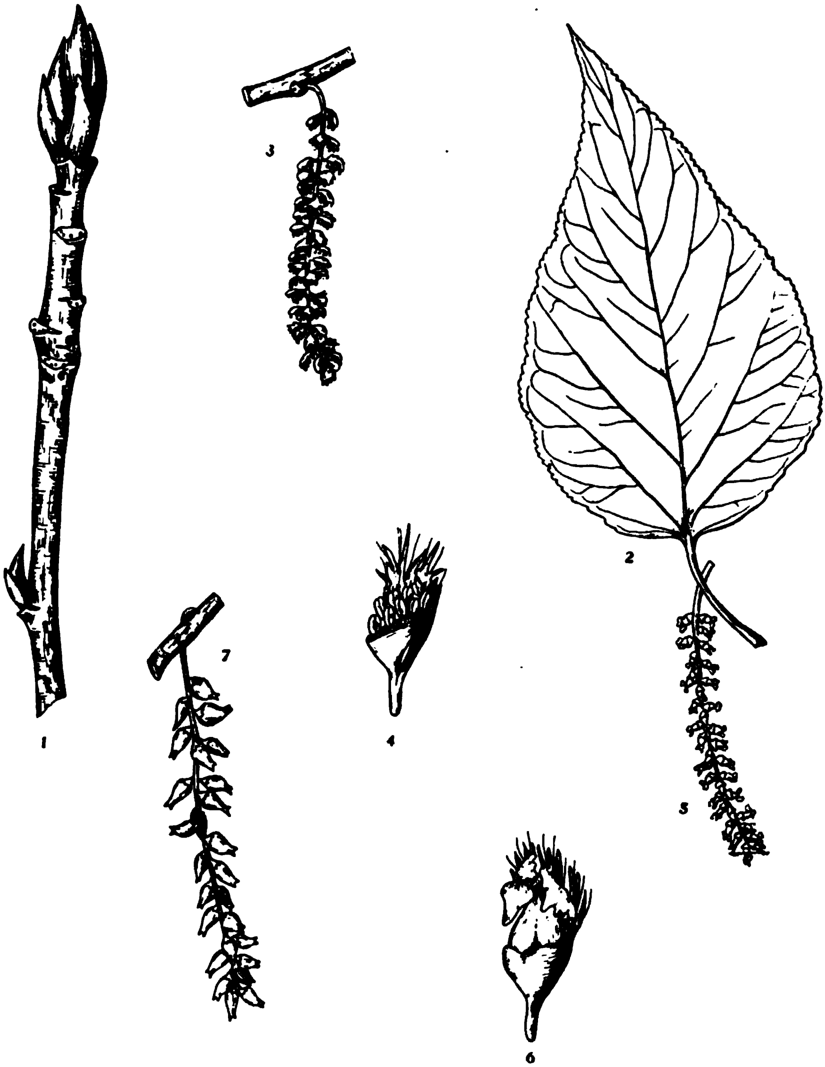
WOOD.—Light, soft, weak, close-grained, light brown, with thin, whitish sapwood.

DISTRIBUTION.—Frequent throughout Vermont.

HABITAT.—Prefers rich, moist, sandy soil; rich woods.

NOTES.—The name of this tree suggests an easy way of identifying it. The coarse-toothed margin of the leaf is a constant characteristic and may be relied upon. The pollen-bearing catkins are seen first, the ovule-bearing catkins appearing a little later on other trees. The fruits ripen when the leaves are unfolding. The young leaves are downy-white on both sides, but later become green and smooth.

Balsam Poplar. Tacamahac



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ¾.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Catkin of pistillate flower, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

SALICACEAE

Balsam Poplar. Tacamahac

Populus balsamifera L.

HABIT.—A tree 50-75 feet high, with a trunk diameter of 1-3 feet; forming a rather narrow, open, pyramidal crown of few, slender, horizontal branches.

LEAVES.—Alternate; simple, 3-6 inches long, about one-half as broad; ovate to ovate-lanceolate; finely crenate-serrate; thin and firm; lustrous, dark green above, paler beneath; petioles 1½ inches long, slender, terete, smooth.

FLOWERS.—April-May, before the leaves; dioecious; the staminate in long-stalked catkins 3-4 inches long; the pistillate in loose-flowered, long-stalked catkins 4-5 inches long; calyx 0; corolla 0; stamens 20-30, with bright red anthers; ovary short-stalked; stigmas 2, wavy-margined.

FRUIT.—May-June; 2-valved, ovoid, short-pedicelled capsules ¼ inch long, borne in drooping catkins 4-6 inches long; seeds light brown, hairy.

WINTER-BUDS.—Terminal bud about 1 inch long, ovoid, long-pointed, brownish, resin-coated, sticky, fragrant.

BARK.—Twigs red-brown, becoming dark orange, finally green-gray; thick, grayish on old trunks, and shallowly fissured into broad, rounded ridges, often roughened by dark excrescences.

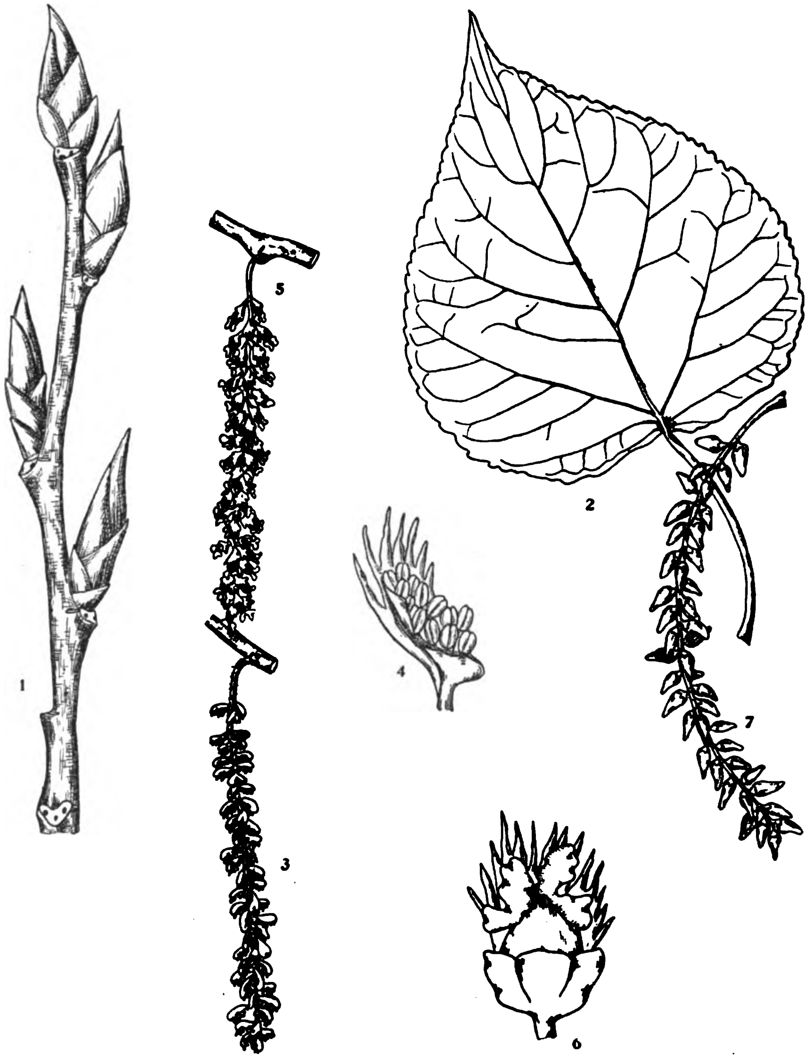
WOOD.—Light, soft, weak, close-grained, light red-brown, with thick, nearly white sapwood.

DISTRIBUTION.—Frequent throughout Vermont; often planted as a shade tree.

HABITAT.—Borders of streams and swamps; wet ravines.

NOTES.—This tree is a northern species ranging from northern New England to the Alaskan coast. It is subject to great variation in the form of the leaves. Some are almost triangular with a deeply heart-shape base, while others are very slender with a wedge-shape base. The buds and young leaves are covered with a gummy excretion which sometimes is soaked out and used in preparing ointments. It is often confused with *P. candicans*, p. 71.

Balm of Gilead



(Mich. Trees).

1. **Winter twig, x 1.**
2. **Leaf, x ½.**
3. **Staminate flowering branchlet, x ½.**
4. **Staminate flower, enlarged.**
5. **Pistillate flowering branchlet, x ½.**
6. **Pistillate flower, enlarged.**
7. **Fruit, x ½.**

SALICACEAE

Balm of Gilead

Populus candicans Ait. [Populus balsamifera candicans (Ait.) Gray]

HABIT.—A tree 50-70 feet high, with a trunk diameter of 1-3 feet; more spreading branches than in *P. balsamifera,* forming a broader and more open crown.

LEAVES.—Resemble those of *P. balsamifera,* but more broadly heart-shaped and more coarsely serrate; more or less pubescent when young; petioles pubescent.

FLOWERS.—Similar to those of *P. balsamifera.*

FRUIT.—Similar to that of *P. balsamifera.*

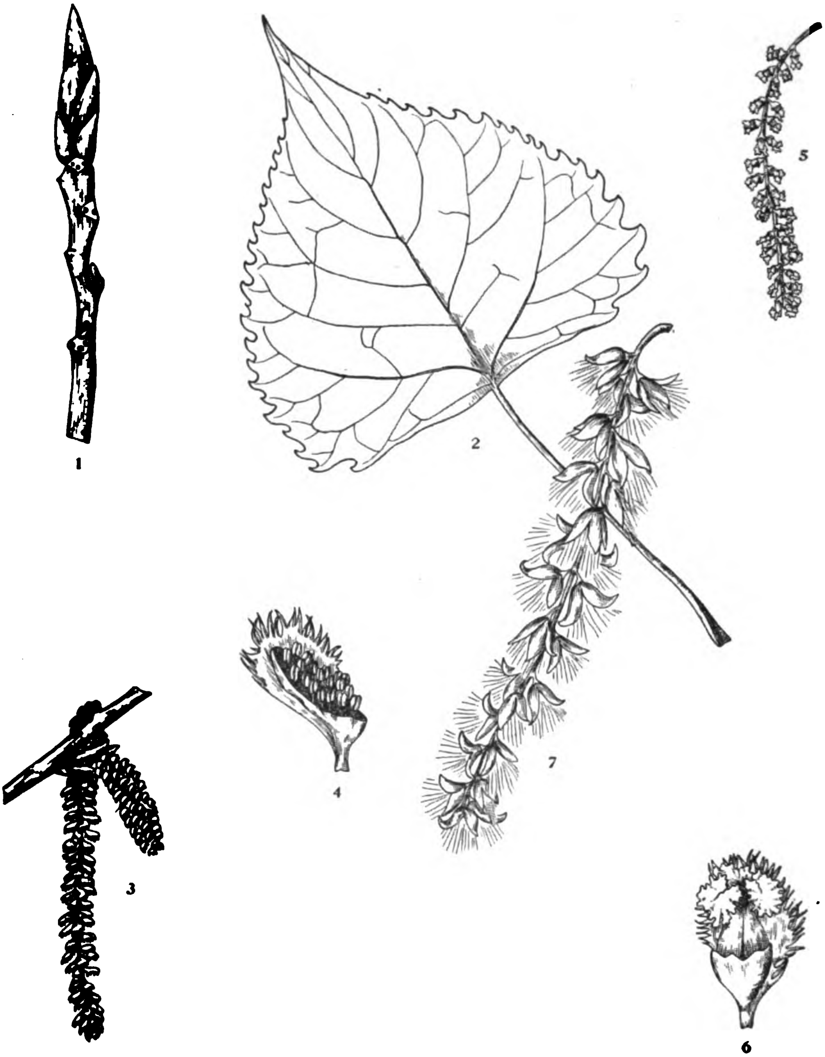
WINTER-BUDS.—Terminal bud about 1 inch long, ovoid, long-pointed, dark red-brown, resinous throughout, viscid, very aromatic.

BARK.—Twigs reddish or olive-green, with occasional longitudinal gray lines, covered with a fragrant, gummy secretion, becoming gray-green; dark gray, rough, irregularly striate and firm on old trunks.

WOOD.—Resembles that of *P. balsamifera,* but is somewhat heavier.

NOTES.—The Balm of Gilead occasionally is cultivated and sometimes escapes to the roadsides. It was long confused with *P. balsamifera.* Further investigation may show it to be a native along our northern border. It grows rapidly in all soils and situations and spreads rapidly by suckers from the roots.

Cottonwood. Necklace Poplar



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate catkin, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

SALICACEAE

Cottonwood. Necklace Poplar

Populus deltoides Marsh. [Populus monilifera Ait.]

HABIT.—A stately tree attaining a height of 70-90 feet and a trunk diameter of 3-5 feet; forming a spreading, open, symmetrical crown of massive, horizontal branches and stout, more or less angled branchlets.

LEAVES.—Alternate, simple, 3-6 inches long, nearly as broad; broadly deltoid-ovate; coarsely crenate-serrate above the entire base; thick and firm; lustrous, dark green above, paler beneath; petioles 2-3 inches long, slender, compressed laterally.

FLOWERS.—April-May, before the leaves; dioecious; the staminate in short-stalked, densely-flowered catkins 3-4 inches long; the pistillate in short-stalked, few-flowered catkins elongating to 6-8 inches; calyx 0; corolla 0; stamens very numerous, with red anthers; stigmas 3-4, spreading.

FRUIT.—May; 2-4-valved, short-stalked capsules, borne in drooping catkins 5-10 inches long; seeds light brown, densely cottony.

WINTER-BUDS.—Terminal bud ½ inch long, conical, acute, very resinous, shining, brownish.

BARK.—Twigs and young stems smooth, yellow-green; old trunks ashy gray, deeply divided into straight furrows with broad, rounded ridges.

WOOD.—Light, soft, weak, close-grained, dark brown, with thick, whitish sapwood; warps badly and is difficult to season.

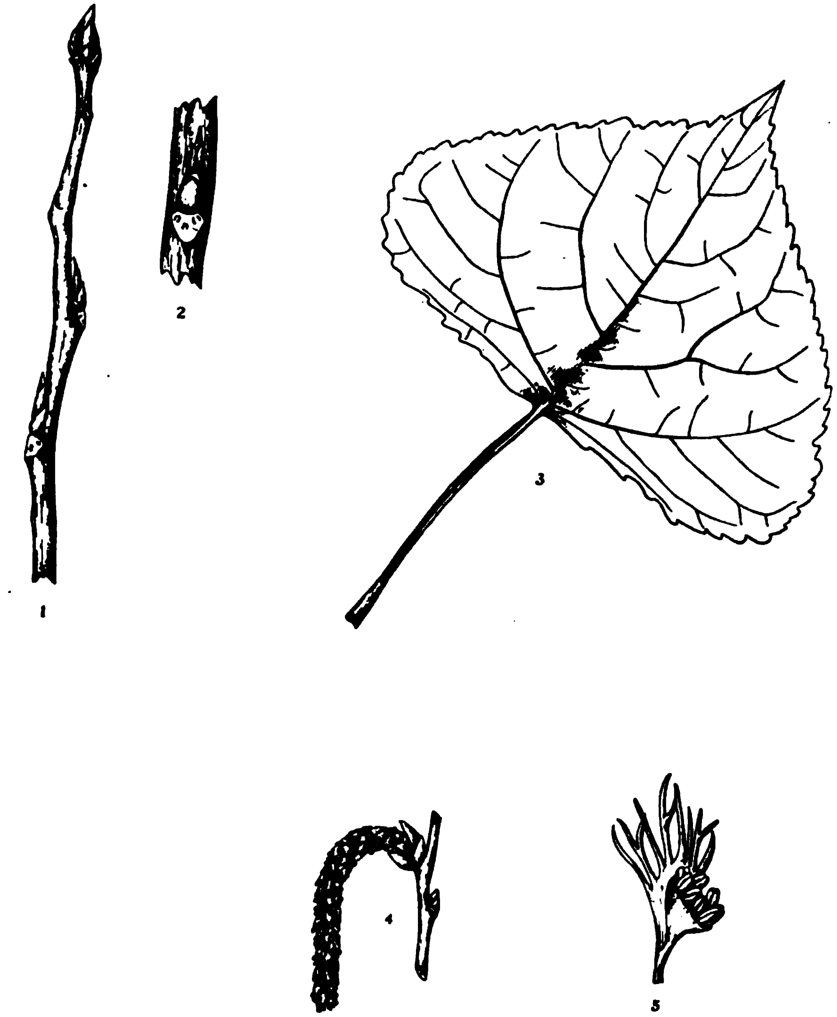
DISTRIBUTION.—Frequent in western Vermont.

HABITAT.—Prefers rich, moist soil, such as river-banks, river-bottoms or lake-shores; grows well in drier situations.

NOTES.—The cottonwood occurs native in the Champlain valley and along its tributary streams, and south in western Vermont to the Hoosic valley in Pownal, where it is particularly abundant. It occurs along the Connecticut river in southeastern Vermont at least as far north as Brattleboro. It has been planted as a shade tree in other localities usually under the name of "Carolina poplar." The stamen-bearing trees always should be chosen for this purpose since the abundant, cottony seed is a nuisance near dwellings.

The cottonwood is the most massive of our deciduous trees, sometimes reaching 100 feet in height and five to seven feet in diameter. Such isolated giants have become the familiar landmarks of many roadsides near Lake Champlain. It is a rapid-growing tree but short-lived and poorly adapted to street planting.

Lombardy Poplar



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ¾.
4. Staminate flowering branchlet, x ½.
5. Staminate flower, enlarged.

SALICACEAE

Lombardy Poplar

Populus nigra italica DuRoi [Populus fastigiata Desf.] [Populus dilatata Ait.]

HABIT.—A tree 75-100 feet high, with a short, ridged and buttressed trunk 4-6 feet in diameter and a narrow, spire-like crown of erect branches.

LEAVES.—Alternate, simple, 2-4 inches long, and usually somewhat broader than long; broad-deltoid, abruptly acuminate at the apex; finely but bluntly crenate-serrate; thick and firm; dark green and shining above, lighter and more or less lustrous beneath; petioles slender, laterally compressed, 1-2 inches long.

FLOWERS.—April-May, before the leaves; dioecious; the staminate in sessile, dark red, cylindrical catkins about 3 inches long; the pistillate not present in the United States; calyx 0; corolla 0; stamens about 8, with white filaments and purple anthers.

FRUIT.—Not formed in the United States in the absence of pistillate flowers.

WINTER-BUDS.—Terminal bud conical, slightly angled, taper-pointed, glutinous, about ⅜ inch long; lateral buds smaller, appressed.

BARK.—Twigs glabrous, shining yellow, becoming gray; thick and gray-brown on old trunks, deeply and irregularly furrowed.

WOOD.—Light, soft, easily worked, not liable to splinter, weak, not durable, light red-brown, with thick, nearly white sapwood.

NOTES.—This tree is thought to be a native of Afghanistan. It is frequently cultivated in Vermont and tends to spread by sprouting from the roots. It is used for ornamental purposes on account of its very rapid growth; but it is short-lived, its limbs die early, and these remain, causing the tree to become unsightly in a very few years.

THE WALNUTS

Every school boy in Vermont has some acquaintance at least with the butternut and its sweet, tender nuts. It occurs along the hillsides and river-valleys throughout the State. The staminate flowers appear in May and hang in graceful, slender catkins five or six inches long. These are generally found on the second-year shoots, while the pistillate flowers are borne on the terminal shoots. Butternut trees show some irregularities, however, in reference to the time and order of the appearance of the two kinds of flowers so that the pollen-bearing clusters may mature either some ten days earlier or later than the ovule-bearing ones on the same tree. This may be the cause of the variability often noticed in the crop of butternuts. The peculiarity offers an interesting subject for further observation.

The meat of the butternut needs no recommendation, but the excellencies of pickles made from the young mucilaginous nuts are not so well known. For this purpose they should be gathered early in June and the clammy pubescence removed by plunging them into boiling water and rubbing with a coarse cloth.

The other member of this family, the black walnut, is not known so well in Vermont. It is not a native tree in Vermont, although it occurs occasionally in Southern New England, becoming more abundant southward and westward. It is planted often for ornamental uses and is a much better tree for this purpose than our native walnut.

SUMMER KEY TO THE SPECIES OF JUGLANS

a. Leaflets 11-17, the terminal usually present; pith of twigs chocolate-brown; bark of trunk rather smooth, or fissured, with broad, flat, whitish ridges; fruit elongated, sticky-downy. . **J. cinerea,** p. 79.

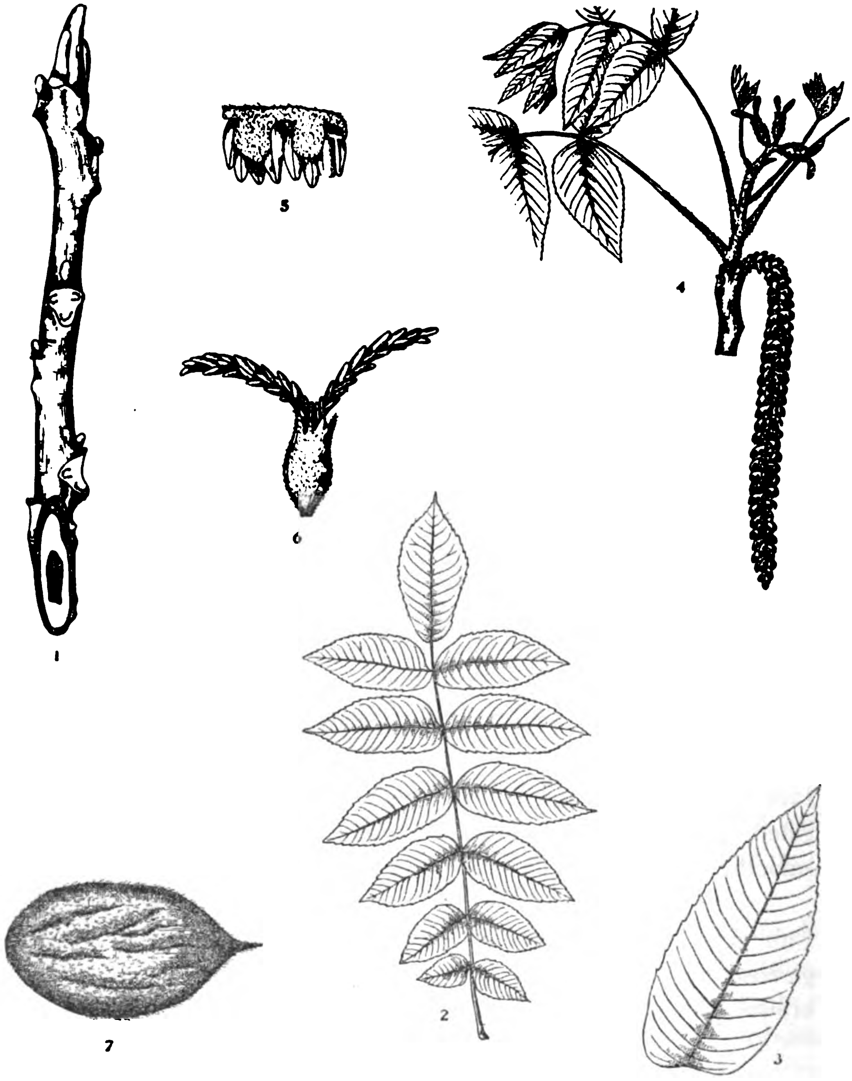
aa. Leaflets 13-23, the terminal often lacking; pith of twigs cream colored; bark of trunk rough, brownish or blackish, deeply furrowed by broad, rounded ridges; fruit globose, not sticky-downy,
J. nigra, p. 81.

WINTER KEY TO THE SPECIES OF JUGLANS

a. Pith chocolate-brown; leaf-scar with downy pad above; fruit elongated, sticky-downy; terminal bud ½-¾ inch long; bark rather smooth, or fissured, with broad, flat, whitish ridges,
J. cinerea, p. 79.

aa. Pith cream colored; leaf-scar without downy pad above; fruit globose, not sticky-downy; terminal bud ⅓ inch long; bark rough, brownish or blackish, deeply furrowed by broad, rounded ridges,
J. nigra, p. 81.

Butternut



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅙.
3. Leaflet, x ½.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

JUGLANDACEAE

Butternut

Juglans cinerea L.

HABIT.—A medium-sized tree 30-50 feet high, with a short trunk 2-3 feet in diameter; forming a wide-spreading crown of large, horizontal branches and stout, stiff branchlets.

LEAVES.—Alternate, compound, 15-30 inches long. Leaflets 11-17, 2-4 inches long and one-half as broad; sessile, except the terminal; oblong-lanceolate; finely serrate; thin; yellow-green and rugose above, pale and soft-pubescent beneath. Petioles stout, hairy.

FLOWERS.—May, with the leaves; monoecious; the staminate in cylindrical, greenish, drooping catkins 3-5 inches long; calyx 6-lobed, borne on a hairy bract; corolla 0; stamens 8-12, with brown anthers; the pistillate solitary or several on a common peduncle, about ⅓ inch long, their bracts and bractlets sticky-hairy; calyx 4-lobed, hairy; corolla 0; styles 2; stigmas 2, fringed, spreading, bright red.

FRUIT.—October; about 2½ inches long, cylindrical, pointed. greenish, sticky-downy, solitary or borne in drooping clusters of 3-5; nuts with rough shells, inclosing a sweet, but oily kernel; edible.

WINTER-BUDS.—Terminal bud ½-¾ inch long, oblong-conical, obliquely blunt, somewhat flattened, brownish, pubescent.

BARK.—Twigs orange-brown or bright green, rusty-pubescent, becoming smooth and light gray; gray and smoothish on young trunks, becoming brown on old trunks, narrow-ridged, with wide furrows. Plate II.

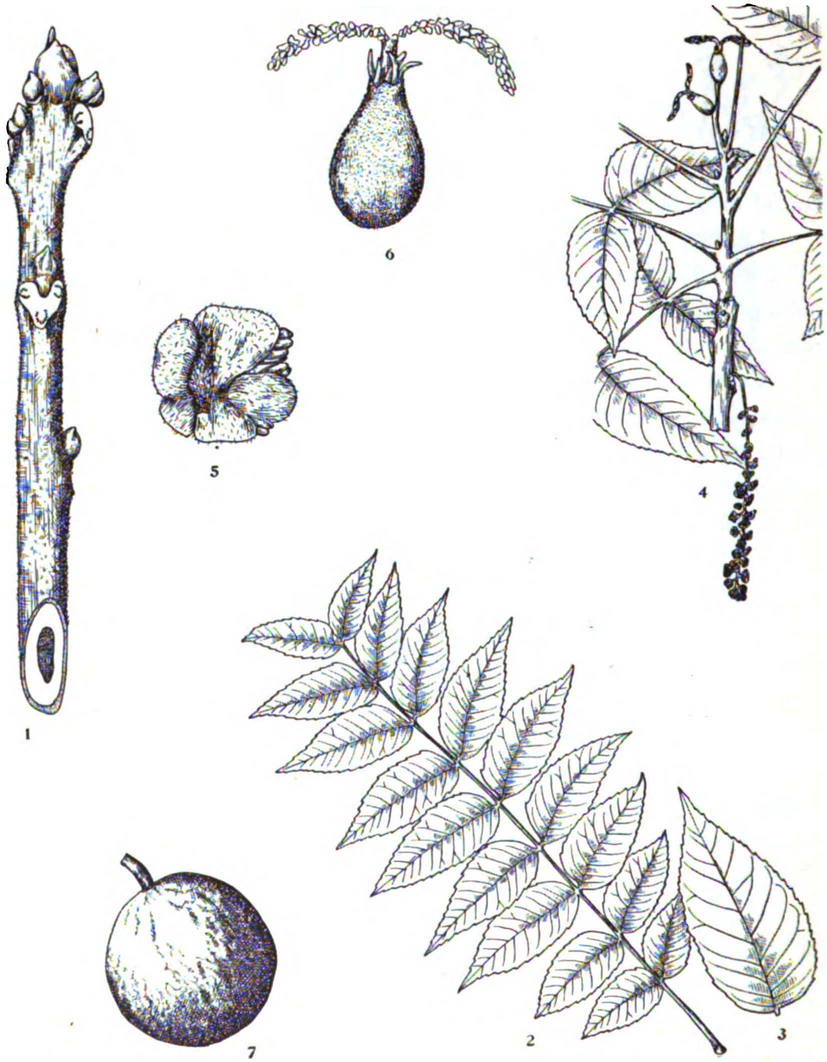
WOOD.—Light, soft, weak, coarse-grained, light brown, with thin, lighter colored sapwood.

DISTRIBUTION.—Of frequent occurrence throughout Vermont.

HABITAT.—Prefers low, rich woods; river-banks; low hillsides; rocky hillsides.

NOTES.—The leaves of the butternut appear late and fall early. The young trees are very attractive but the larger trees usually are scraggy and unsound. Some preliminary work done in Dorset, Bennington County, seems to indicate that perhaps through some peculiar root antagonism the butternut will kill the shrubby cinquefoil (*Potentilla fructicosa*), a shrub which is destroying some of the best pastures in Northwestern Connecticut, Berkshire County, Massachusetts and Bennington and Rutland Counties, Vermont.

Black Walnut



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅛.
3. Leaflet, x ½.
4. Flowering branchlet, x ½.
5. Staminate flower, back view, enlarged.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

JUGLANDACEAE

Black Walnut

Juglans nigra L.

HABIT.—A large tree 50-75 feet high, with a massive trunk 2-5 feet in diameter; forming an open, capacious crown of heavy branches and coarse branchlets.

LEAVES.—Alternate, compound, 1-2 feet long. Leaflets 13-23, the terminal often lacking, 2-4 inches long and one-half as broad; sessile; ovate-lanceolate, taper-pointed; sharp-serrate; thin; yellow-green and glabrous above, lighter and soft-pubescent beneath. Petioles stout, pubescent. Foliage aromatic when bruised.

FLOWERS.—May, with the leaves; monoecious; the staminate in cylindrical, greenish, drooping catkins 3-5 inches long; calyx 6-lobed, borne on a hairy bract; corolla 0; stamens numerous, with purple anthers; the pistillate solitary or several on a common peduncle, about ¼ inch long, their bracts and bractlets hairy; calyx 4-lobed, pubescent; corolla 0; styles and stigmas 2.

FRUIT.—October; globose, 1½-2 inches in diameter, smooth, not viscid; solitary or borne in clusters of 2-3; nuts with irregularly furrowed shell, inclosing a sweet, edible kernel; aromatic.

WINTER-BUDS.—Terminal bud ⅓ inch long, ovoid, obliquely blunt, slightly flattened, silky-tomentose.

BARK.—Twigs brownish and hairy, becoming darker and smooth; thick, brownish or blackish on the trunk and deeply furrowed by broad, rounded ridges.

WOOD.—Heavy, hard, strong, close-grained, very durable in contact with the soil, rich dark brown, with thin, lighter colored sapwood.

NOTES.—The black walnut was once very abundant, especially in the Mississippi basin, where it grew to a height of 150 feet. It is valued for its nuts and beautiful wood. It prefers rich bottom-lands and fertile hillsides. The leaves appear late and fall early. One great drawback to its use in ornamental planting is the fact that it is so often infested with caterpillars.

THE HICKORIES

The hickories are stately trees, quite generally distributed throughout the United States. There are eight species, all peculiar to America, several of which produce edible nuts. Among the latter are the shellbark hickory in the north and the pecan in the south.

The flowers, arranged in catkins of the two kinds, appear in late spring after the unfolding of the leaves.

The wood of all these trees is heavy, tough and durable. It is used for axe handles, agricultural implements, and in places where strength and elasticity are required it is almost unrivaled.

The hickories frequently but erroneously are termed "walnuts" in the popular language of New England. The true walnuts, of which the butternut and black walnut are the American representatives, differ from the hickories, although they are closely related.

SUMMER KEY TO THE SPECIES OF CARYA

a. Bark of trunk essentially smooth, not deeply furrowed nor shaggy; husk of fruit less than 1/8 inch thick.

b. Leaflets usually 5-7, glabrous beneath, the upper 2-2½ inches broad; buds dome-shaped, greenish; kernel of nut sweet, **C. glabra,** p. 89.

bb. Leaflets usually 7-11, more or less downy beneath, the upper 1-1½ inches broad; buds long-pointed, flattish, bright yellow; kernel of nut bitter .... **C. cordiformis,** p. 91.

aa. Bark of trunk deeply furrowed or shaggy; husk of fruit more than 1/8 inch thick.

b. Twigs more or less pubescent; bark not shaggy; leaflets 5-7, more or less pubescent beneath; buds densely hairy, **C. alba,** p. 87.

bb. Twigs tending to be glabrous; bark distinctly shaggy; leaflets usually 5, glabrous beneath; buds glabrous or nearly so, **C. ovata,** p. 85.

WINTER KEY TO THE SPECIES OF CARYA

a. Bark of trunk essentially smooth, not deeply furrowed nor shaggy; husk of fruit less than 1/8 inch thick.

b. Terminal bud narrow, long-pointed, flattish, bright yellow, about ¾ inch long; kernel of nut bitter....... **C. cordiformis,** p. 91.

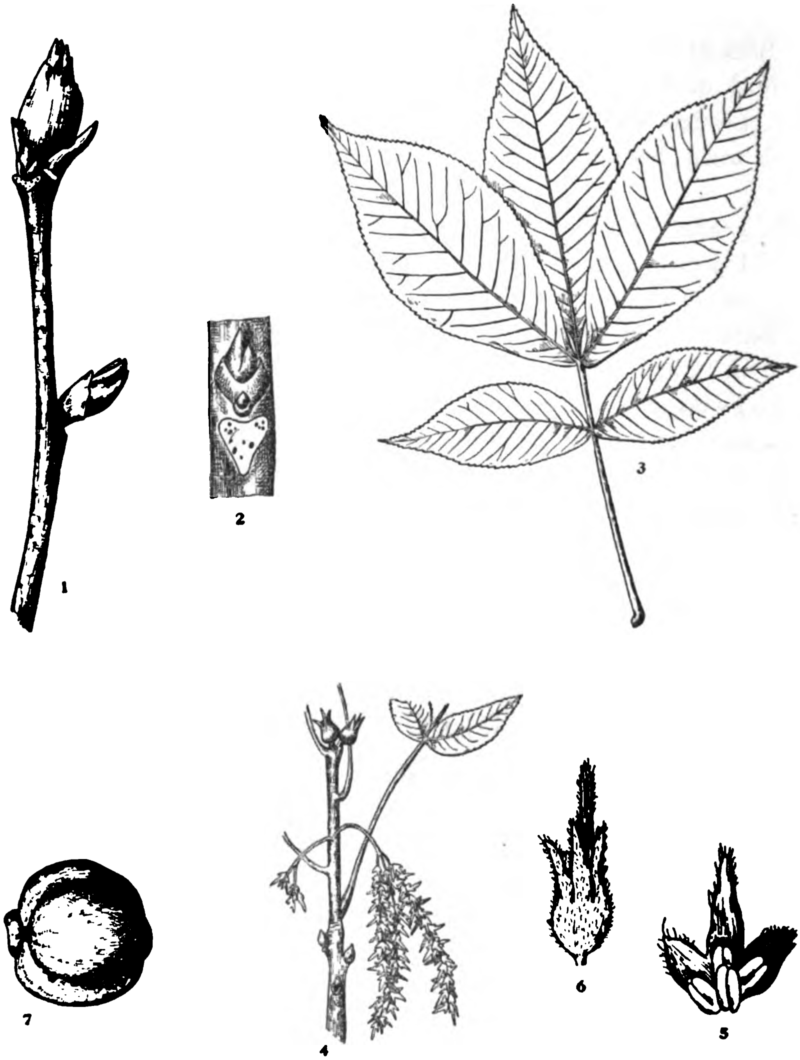
bb. Terminal bud broad, dome-shaped, greenish, ¼-½ inch long; kernel of nut sweet .... **C. glabra,** p. 89.

aa. Bark of trunk deeply furrowed or shaggy; husk of fruit more than 1/8 inch thick.

b. Twigs more or less pubescent; buds densely hairy, the outer bud-scales deciduous in autumn; bark not shaggy. . **C. alba,** p. 87.

bb. Twigs tending to be glabrous; buds glabrous or nearly so, the outer bud-scales not deciduous in autumn; bark distinctly shaggy .... **C. ovata,** p. 85.

Shellbark Hickory. Shagbark Hickory



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ⅓.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

JUGLANDACEAE

Shellbark Hickory. Shagbark Hickory

Carya ovata (Mill.) K. Koch [Hicoria ovata (Mill.) Britt.] [Carya alba Nutt.]

HABIT.—A tree 50-75 feet high, with a slender, columnar trunk 1-2 feet in diameter; forming a narrow, somewhat open crown of stout, slightly spreading limbs and stout branchlets.

LEAVES.—Alternate, compound, 8-14 inches long. Leaflets usually 5, the upper 5-7 inches long and 2-3 inches broad; sessile, except the terminal; obovate to oblong-lanceolate; finely serrate; thick and firm; glabrous, dark green above, paler beneath and glabrous or puberulous. Petioles stout, smooth or hairy. Foliage fragrant when crushed.

FLOWERS.—May-June, after the leaves; monoecious; the staminate hairy, greenish, in pendulous, ternate catkins 4-5 inches long, on a common peduncle about 1 inch long; scales 3-parted, bristle-tipped; stamens 4, with bearded, yellow anthers; the pistillate in 2-5-flowered spikes, ⅓ inch long, brown-tomentose; calyx 4-lobed, hairy; corolla 0; stigmas 2, large, fringed.

FRUIT.—October; globular, 1-2 inches long, with thick husk separating completely; nut usually 4-ridged, with thick shell and large, sweet, edible kernel.

WINTER-BUDS.—Terminal bud ½-¾ inch long, broadly ovoid, obtuse, dark brown, pale-tomentose or nearly glabrous.

BARK.—Twigs brownish, more or less downy, becoming smooth and grayish; thick and grayish on old trunks, separating into thick strips 1-3 feet long, free at one or both ends, giving a characteristic shaggy appearance. Plate II.

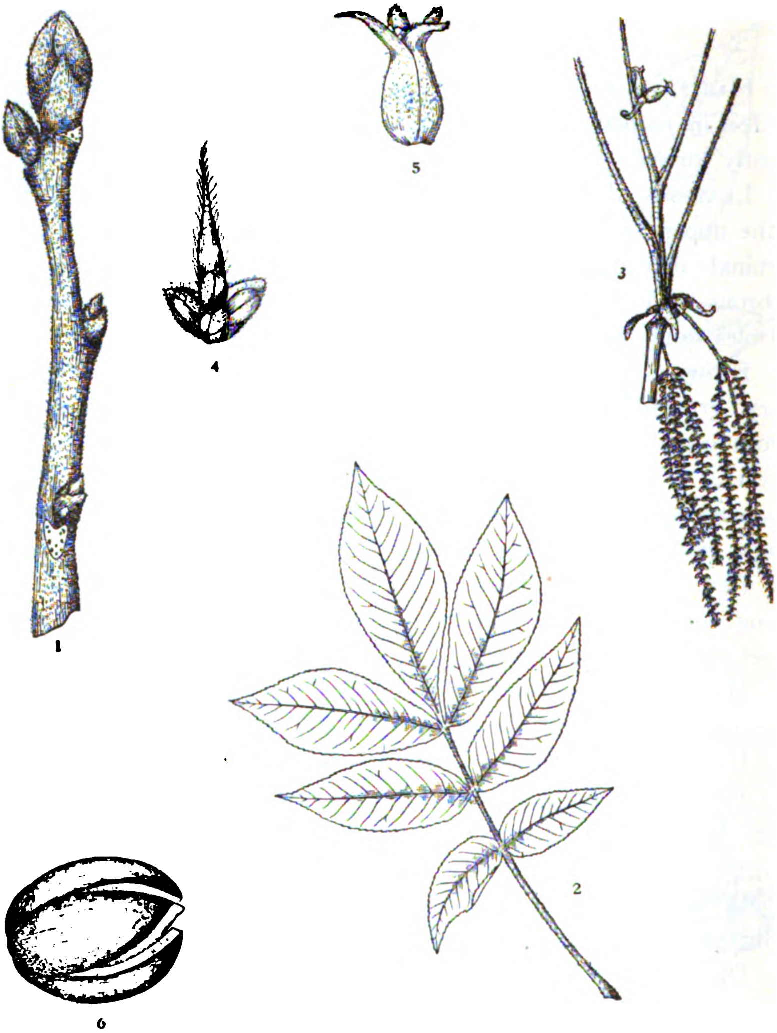
WOOD.—Heavy, very hard and strong, tough, close-grained, elastic, light brown, with thin, whitish sapwood. Page 229.

DISTRIBUTION.—Frequent in the lower altitudes west of the Green mountains; known in the Connecticut valley as far north as Bellows Falls; a large grove on the south side of Bald Mountain in Shrewsbury at an altitude of about 1,500 feet.

HABITAT.—Prefers light, well-drained, loamy soil; low hillsides; river-banks.

NOTES.—The shellbark hickory is one of our most attractive trees. It is known to every boy who lives in its range by its shaggy bark and its excellent nuts.

Mocker Nut. White Heart Hickory



(Mich. Trees).

1. **Winter twig, x 1.**
2. **Leaf, x ⅓.**
3. **Flowering branchlet, x ½.**
4. **Staminate flower, enlarged.**
5. **Pistillate flower, enlarged.**
6. **Fruit, x ½.**

JUGLANDACEAE

Mocker Nut. White Heart Hickory

Carya alba (L.) K. Koch [Hicoria alba (L.) Britt.] [Carya tomentosa Nutt.]

HABIT.—A tree 50-70 feet high, with a trunk diameter of 1-2½ feet; forming a wide crown of strong, upright branches and stout branchlets.

LEAVES.—Alternate, compound, 8-12 inches long. Leaflets usually 5-7, sometimes 9, the upper 5-8 inches long, 3-4 inches broad; sessile, except the terminal; oblong- to obovate-lanceolate; minutely or sometimes coarsely serrate; thick and firm; lustrous, dark yellow-green above, paler and more or less pubescent beneath. Petioles pubescent. Foliage fragrant when crushed.

FLOWERS.—May-June, after the leaves; monoecious; the staminate in pendulous, ternate catkins 4-5 inches long, slender, green, hairy; scales 3-lobed, hairy; stamens 4-5, with red anthers; the pistillate in crowded, 2-5-flowered, tomentose spikes; calyx toothed, hairy; corolla 0; stigmas 2, hairy.

FRUIT.—October; globose to globose-oblong, 1½-2 inches long, with thick husk splitting nearly to the base; nut 4-ridged, red-brown, with very thick, hard shell and small, sweet kernel.

WINTER-BUDS.—Terminal bud ½-¾ inch long, broadly ovoid, red-brown, pilose; outermost scales fall in early autumn.

BARK.—Twigs at first brown-tomentose, becoming smooth and grayish; on the trunk thick, hard, grayish, slightly ridged by shallow, irregular fissures, becoming rugged on very old trunks.

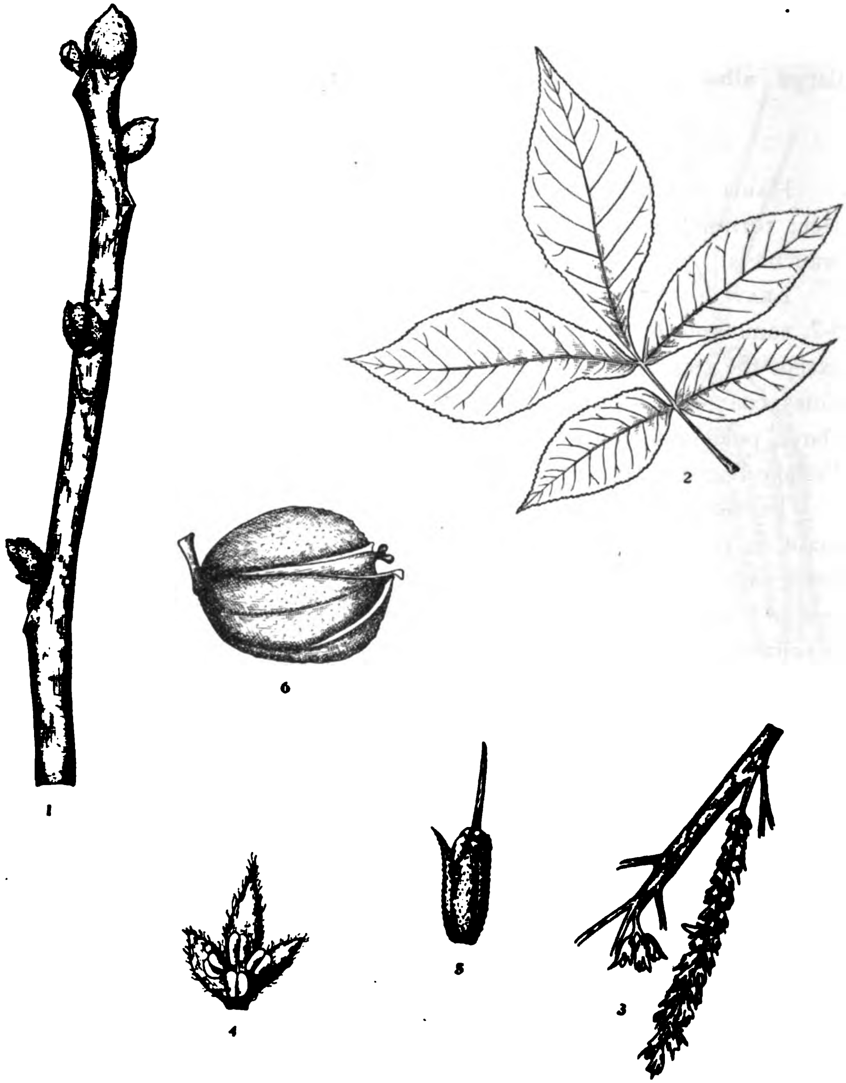
WOOD.—Very heavy, hard, strong, tough, close-grained, elastic, dark brown, with thick, whitish sapwood.

DISTRIBUTION.—Reported from Burlington and West Haven; probably occurs in other localities in the lower altitudes of the southern half of the State.

HABITAT.—Prefers rich, well-drained soil, but grows well in various situations, if they are not too wet.

NOTES.—This tree probably is not distinguished by most observers from *C. ovata,* which it closely resembles; there is need of further and more thorough investigation of this species.

Pignut



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ¼.
3. Flowering branchlet, x 1.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

JUGLANDACEAE

Pignut

Carya glabra (Mill.) Spach. [Hicoria glabra (Mill.) Britt.]
[Carya porcina Nutt.]

HABIT.—A tree usually 50-60 feet high, with a trunk diameter of 1-3 feet; forming a low, rather narrow, open crown of slender, often contorted branches.

LEAVES.—Alternate, compound, 8-12 inches long. Leaflets usually 5-7, the upper 3-6 inches long, 2-2½ inches broad; sub-sessile, except the terminal; oblong to obovate-lanceolate, taper-pointed; sharply serrate; thick and firm; glabrous, dark yellow-green above, paler beneath. Petioles long, slender, glabrous or pubescent. Foliage fragrant when crushed.

FLOWERS.—May-June, after the leaves; monoecious; the staminate in pendulous, ternate catkins 3-7 inches long, slender, yellow-green, tomentose; scales 3-lobed, nearly glabrous; stamens 4, with orange anthers; the pistillate in crowded, 2-5-flowered spikes, ¼ inch long; calyx 4-toothed, hairy; corolla 0; stigmas 2, yellow.

FRUIT.—October; variable in size and shape, 1½-2 inches long, with thin husk splitting half-way and sometimes nearly to the base; nut obscurely 4-ridged, with thin or thick, hard shell and small, sweet or slightly bitter kernel which is hard to remove.

WINTER-BUDS.—Terminal bud ¼-½ inch long, dome-shaped, greenish or grayish, smooth or finely downy.

BARK.—Twigs greenish, nearly glabrous, becoming reddish, and finally grayish; thick, hard and grayish on the trunk, with a firm, close surface divided by small fissures and sometimes broken into plates. Plate II.

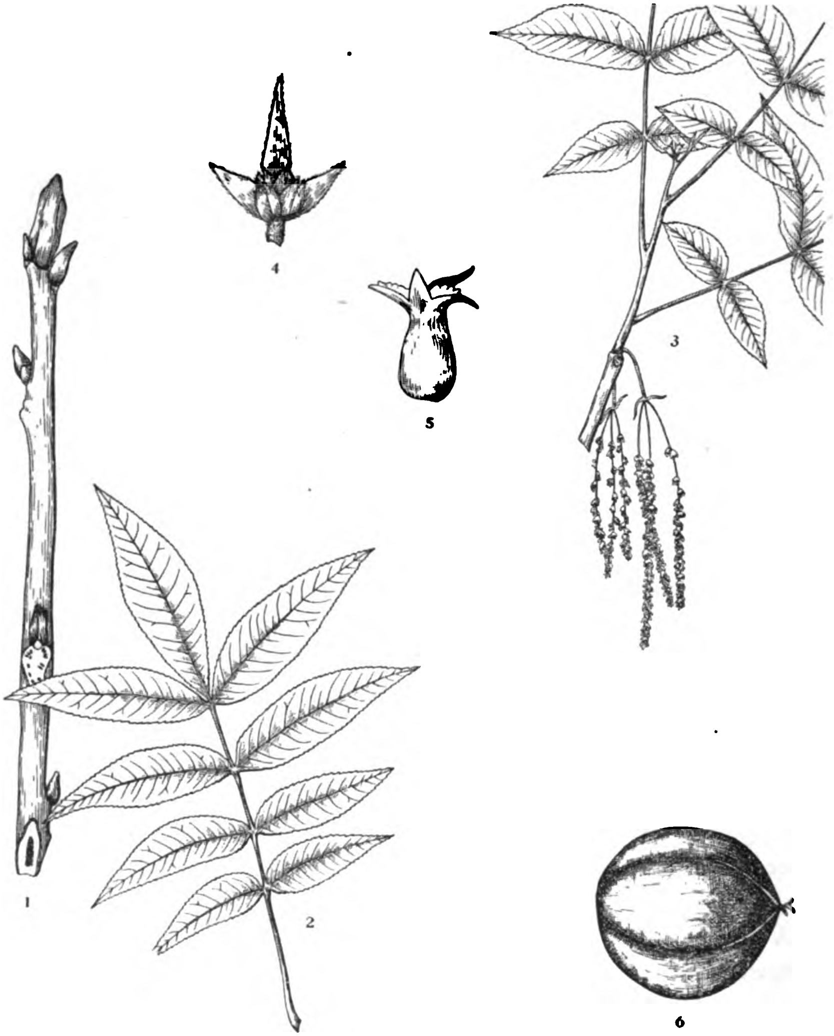
WOOD.—Heavy, hard, very strong, tough, close-grained, elastic, dark brown, with thick, whitish sapwood.

DISTRIBUTION.—Occurs in the southern portion of Vermont.

HABITAT.—Prefers deep, rich loam, but grows in any well-drained soil; dry ridges and hillsides.

NOTES.—This is a common tree in the Hoosic valley, Pownal, and a large grove occurs on the shore of Lake Bomoseen, West Castleton (Eggleston). There are a few trees near the Hubbardton line in East Castleton (G. H. Ross). In the Connecticut valley it is abundant on the hills near the river in the vicinity of the Massachusetts line, but is not common above Bellows Falls (Flint). Observers of trees in southern Vermont should strive further to increase our knowledge of its distribution.

Bitternut Hickory



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅓.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

JUGLANDACEAE

Bitternut Hickory

Carya cordiformis (Wang.) K. Koch [Hicoria minima (Marsh.) Britt.] [Carya amara Nutt.]

HABIT.—A tall, slender tree 50-75 feet high, with a trunk diameter of 1-2½ feet; forming a broad crown of slender, stiff, upright branches, widest near the top.

LEAVES.—Alternate, compound, 6-10 inches long. Leaflets 5-11, the upper 4-6 inches long and one-fourth as broad; sessile, except the terminal; lanceolate to oblong-lanceolate, long-pointed; coarsely serrate; thin and firm; glabrous, bright green above, paler and more or less downy beneath. Petioles slender, hairy. Foliage fragrant when crushed.

FLOWERS.—May-June, after the leaves; monoecious; the staminate slightly pubescent, in pendulous, ternate catkins 3-4 inches long, on a common peduncle about 1 inch long; scale 3-lobed, hairy; stamens 4, with bearded, yellow anthers; the pistillate in 2-5-flowered spikes, ½ inch long, scurfy-tomentose; calyx 4-lobed, pubescent; corolla 0; stigmas 2, greenish.

FRUIT.—October; obovate to globular, about 1 inch long, coated with yellow, scurfy pubescence, with very thin husk splitting half-way to the base, with sutures winged at the top; nut quite smooth, with thin shell and small, bitter kernel.

WINTER-BUDS.—Terminal bud about ¾ inch long, long-pointed, flattish, granular-yellow; lateral buds more or less 4-angled.

BARK.—Twigs greenish and more or less downy, becoming brownish, and finally grayish; gray, close, smooth on the trunk, often reticulately ridged, but rarely broken into plates. Plate III.

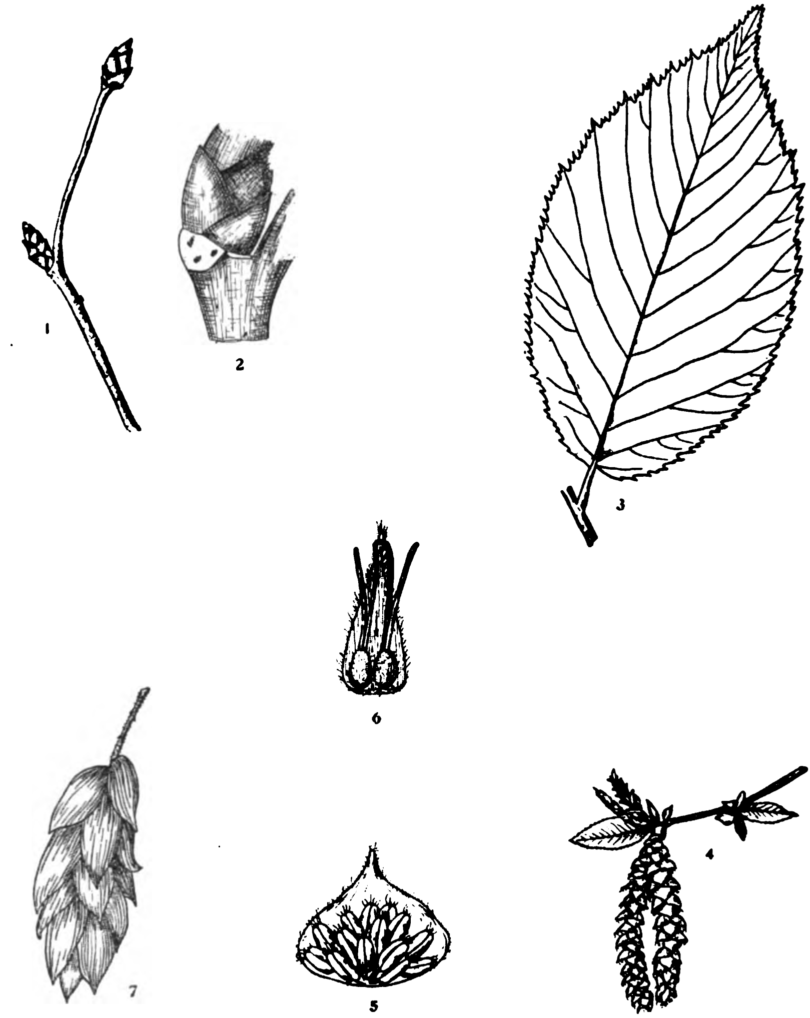
WOOD.—Heavy, very hard, strong, tough, close-grained, dark brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Frequent in the lower altitudes west of the Green mountains and known in the Connecticut valley as far north as Hartland.

HABITAT.—Prefers a rich, loamy soil; low, wet woods; along the borders of streams.

NOTES.—The bitternut grows most rapidly of all the hickories, but it is apt to show dead branches. It should be propagated from the seed, as it is not easily transplanted. The yellow buds at once distinguish it from all other hickories.

American Hop Hornbeam. Leverwood



(Mich. Trees).

1. Winter twig, x ½.
2. Portion of twig, enlarged.
3. Leaf, x ½.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

BETULACEAE

American Hop Hornbeam. Leverwood

Ostrya virginiana (Mill.) K. Koch

HABIT.—A small tree usually 20-30 feet high, with a trunk diameter of 8-12 inches; forming a broad, rounded crown of many long, slender branches and a slender, stiff spray.

LEAVES.—Alternate, simple, 3-5 inches long, about one-half as broad; oblong-ovate; sharply doubly serrate; thin and very tough; dull, dark green above, paler and more or less pubescent beneath; petioles short, slender, pubescent.

FLOWERS.—May, with the leaves; monoecious; the staminate in drooping, cylindrical catkins from wood of the previous season, usually in threes; stamens 3-14, crowded on a hairy torus; the pistillate in erect, lax catkins on the season's shoots, usually in pairs, each flower inclosed in a hairy, sac-like involucre.

FRUIT.—September; strobiles, resembling clusters of hops, 1-2 inches long, borne on slender, hairy stems; nuts small and flat, inclosed by sac-like involucres.

WINTER-BUDS.—Terminal but absent; lateral buds ⅛-¼ inch long, ovoid, acute, red-brown.

BARK.—Twigs at first light green, becoming lustrous, red-brown, and finally dull dark brown; thin, gray-brown on the trunk, very narrowly and longitudinally ridged. Plate III.

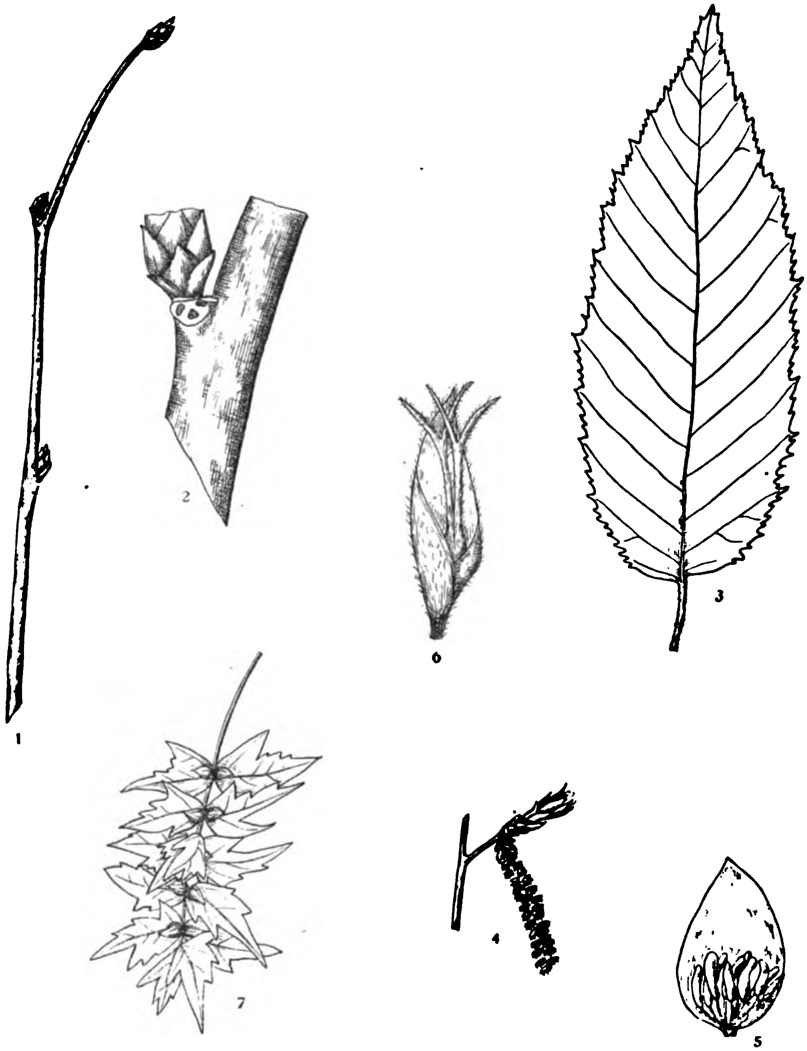
WOOD.—Heavy, very strong and hard, tough, close-grained, durable, light red-brown, with thick, whitish sapwood.

DISTRIBUTION.—Common to both valleys and mountains of Vermont, but more abundant in the western and southern portions.

HABITAT.—Rich woods; open woods; slopes and ridges.

NOTES.—Hornbeams sometimes are mistaken and transplanted for elms, owing to the general similarity in the appearances of the young trees. The leaves of the hornbeam, however, are nearly symmetrical at the base, while those of the elm are more unequally developed. In late summer the hornbeam is easily distinguished by its fruit hanging in hop-like heads. The hornbeam is distributed, quite generally, both in the valleys and the mountainous parts of Vermont, but is most common in western and southern portions. It is a small tree. The wood is very strong, tough and durable in contact with the soil, hence the names ironwood, leverwood. It is used for levers, mallets and for fencing materials.

American Hornbeam. Blue Beech. Water Beech



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

BETULACEAE

American Hornbeam. Blue Beech. Water Beech

Carpinus. caroliniana Walt.

HABIT.—Usually a low, bushy tree or large shrub, 10-30 feet high, with a trunk diameter of 6-12 inches; trunk short, usually fluted; slender zigzag branches and a fine spray form a close, flat-topped crown.

LEAVES.—Alternate, simple, 2-4 inches long and one-half as broad; ovate to oval, long-pointed; sharply doubly serrate; thin and firm; dull green above, lighter beneath, turning scarlet and orange in autumn; petioles short, slender, hairy.

FLOWERS.—May, after the leaves; monoecious; apetalous; the staminate catkins 1-1½ inches long, their scales greenish, boat-shaped, each bearing 3-20 stamens; the pistillate catkins ½-¾ inch long, their scales hairy, greenish, each bearing 2 pistils with long, scarlet styles.

FRUIT.—Ripens in midsummer, but often remains on the tree long after the leaves have fallen; in loose, terminal strobiles; involucre halberd-shaped, inclosing a small, ovate, brownish nut.

WINTER-BUDS.—Terminal bud absent; lateral buds ⅛ inch long, narrow-ovoid, acute, puberulous, brownish.

BARK.—Twigs pale green, hairy, becoming lustrous, dark red the first winter; trunk and large limbs thin, smooth, close, dark bluish gray, often mottled with lighter or darker patches.

WOOD.—Heavy, hard, tough, very strong, close-grained, light brown, with thick, whitish sapwood.

DISTRIBUTION.—Frequent throughout Vermont at the lower altitudes.

HABITAT.—Deep, rich, moist soil along the borders of streams and swamps. Often found in drier situations in the shade of other trees.

NOTES.—The blue beech is a small, bushy tree rarely over twenty feet high. It is not uncommon in moist soil along streams, but does not reach the higher altitudes. It is distinguished in spring by its tiny flowers arranged in loose catkins and in July by the curious leaf-like wings which develop upon the fruit. A glance at its trunk makes its recognition certain at any time of year. It has a close, gray bark resembling that of the beech but with furrows and ridges suggesting the muscles of a strong man's arm. It is the toughest of all our woods.

THE BIRCHES

The birches are distributed widely over the Old and the New Worlds, being most abundant in the higher latitudes. Nine species occur in North America, four of which are found in Vermont. They are all graceful trees with slender flexuous branches and delicate foliage. Both the ovule-bearing and pollen-bearing flowers are found on the same tree, but in separate clusters. The staminate catkins are long and drooping, while the pistillate are shorter and not pendulous until fruited.

The wood of birches is valued chiefly for cabinet making, spools and other small articles.

SUMMER KEY TO THE SPECIES OF BETULA

a. Bark of trunk chalky-white; twigs without wintergreen taste.

b. Twigs usually warty-glandular; bark of trunk not separating freely into thin, papery layers; inner bark dingy yellow; leaves nearly triangular to rhombic-ovate, long-pointed; small tree, with trunk 6-10 inches in diameter..... **B. populifolia,** p. 103.

bb. Twigs not warty-glandular; bark of trunk separating freely into thin, papery layers, exposing the bright cinnamon-yellow inner bark; leaves ovate, not long-pointed; large tree, with trunk 1-3 feet in diameter .... **B. alba papyrifera,** p. 105.

aa. Bark of trunk not chalky-white, usually dark colored; twigs with more or less wintergreen taste.

b. Bark dirty yellow, breaking into strips more or less curled at the edges; leaves solitary or in pairs, slightly aromatic; twigs with slight wintergreen taste .... **B. lutea,** p. 101.

bb. Bark dark red-brown, cleaving off in thick, irregular plates (resembles bark of black cherry); leaves in pairs, strongly aromatic; twigs with strong wintergreen taste.......... **B. lenta,** p. 99.

WINTER KEY TO THE SPECIES OF BETULA

a. Bark of trunk chalky-white; twigs without wintergreen taste.

b. Twigs usually warty-glandular; bark of trunk not separating freely into thin, papery layers; inner bark dingy yellow; small tree, with trunk 6-10 inches in diameter... **B. populifolia,** p. 103.

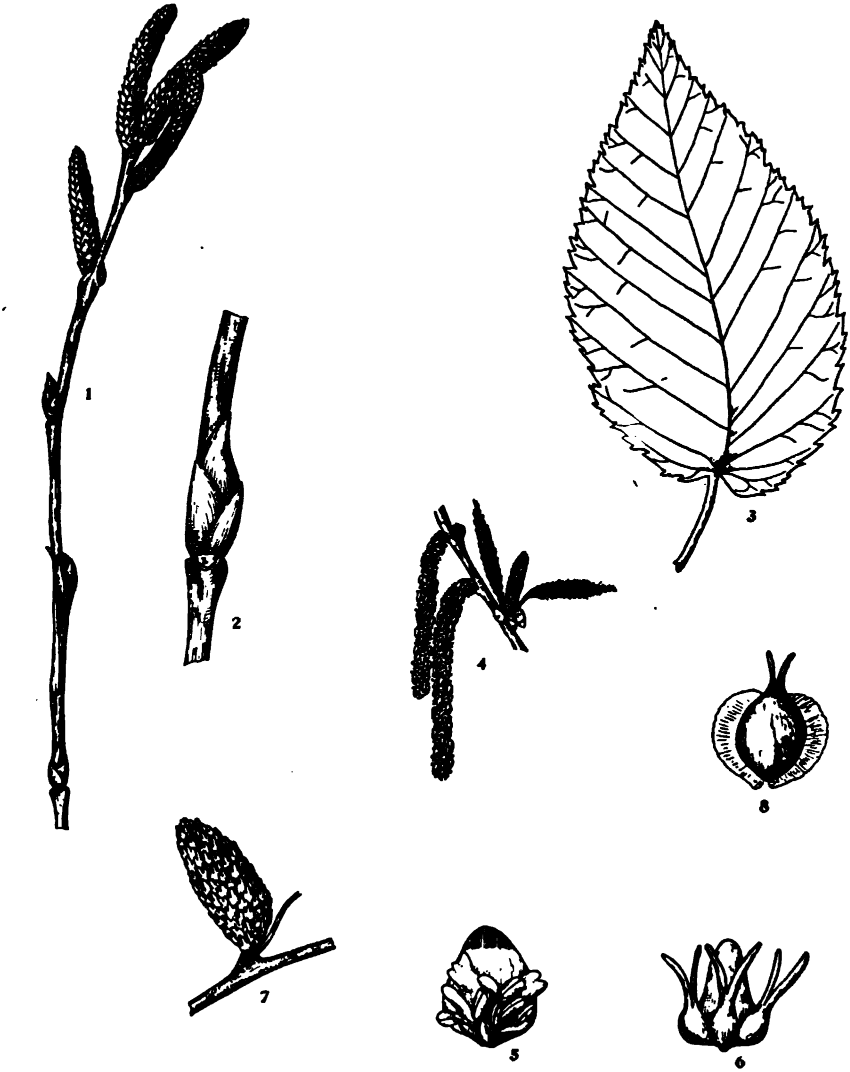
bb. Twigs not warty-glandular; bark of trunk separating into thin, papery layers, exposing the bright cinnamon-yellow inner bark; large tree, with trunk 1-3 feet in diameter, **B. alba papyrifera,** p. 105.

aa. Bark of trunk not chalky-white, usually dark colored; twigs with more or less wintergreen taste.

b. Bark dirty yellow, breaking into strips more or less curled at the edges; twigs with slight wintergreen taste... **B. lutea,** p. 101.

bb. Bark dark red-brown, cleaving off in thick, irregular plates (resembles bark of black cherry); twigs with strong wintergreen taste .... **B. lenta,** p. 99.

Cherry Birch. Sweet Birch. Black Birch



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ½.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruiting branchlet, x ½.
8. Fruit, enlarged.

BETULACEAE

Cherry Birch. Sweet Birch. Black Birch

Betula lenta L.

HABIT.—A medium-sized tree 50-75 feet high, with a trunk diameter of 1-3 feet; slender, wide-spreading, pendulous branches, forming a narrow, rounded, open crown.

LEAVES.—Alternate in pairs, simple, 3-4 inches long and one-half as broad; outline variable, ovate to oblong-ovate; sharply doubly serrate, with slender, incurved teeth; dull, dark green above, light yellow-green beneath; petioles short, stout, hairy, deeply grooved above; aromatic.

FLOWERS.—April-May, before the leaves; monoecious; the staminate catkins 3-4 inches long, slender, pendent, yellowish; the pistillate catkins ½-¾ inch long, erect or suberect, greenish.

FRUIT.—Ripens in autumn; sessile, glabrous, erect strobiles, 1-1½ inches long and half as thick; scales glabrous; nuts slightly broader than their wings.

WINTER-BUDS.—Terminal bud absent; lateral buds about ¼ inch long, conical, sharp-pointed, red-brown, divergent.

BARK.—Twigs light green, becoming lustrous, red-brown in their first winter; very dark on old trunks, cleaving off in thick, irregular plates. Resembles bark of black cherry. Inner bark aromatic, spicy.

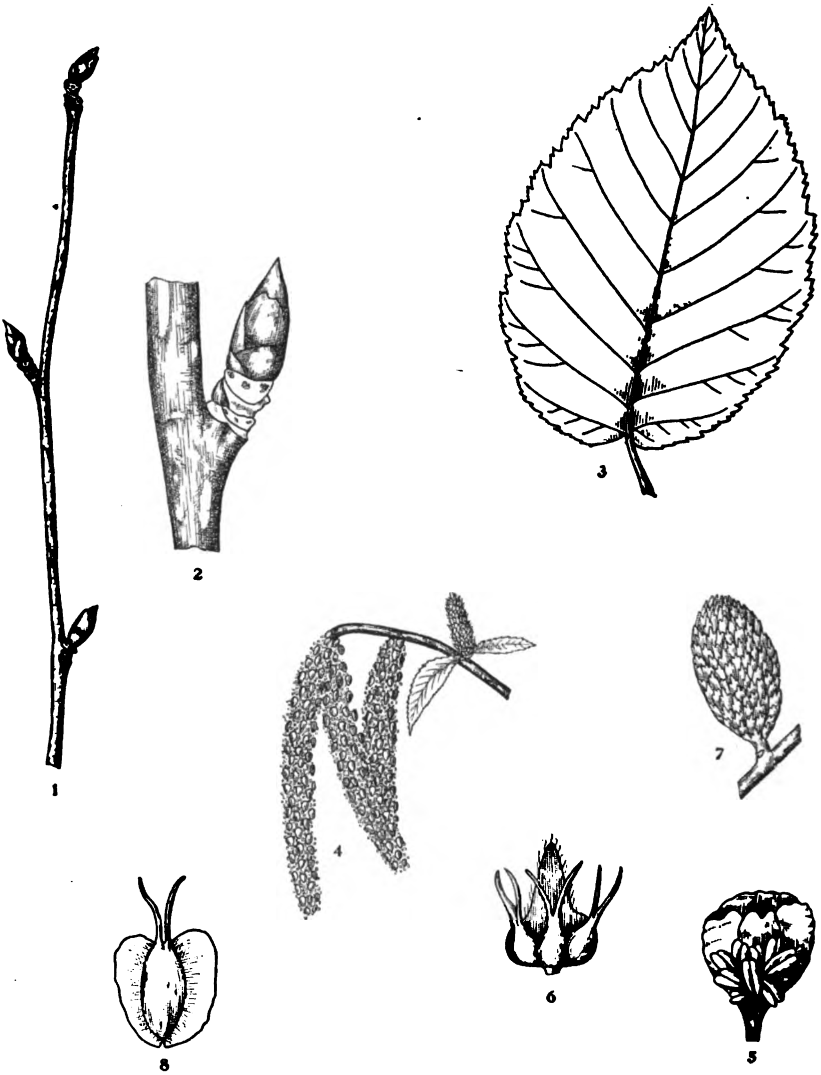
WOOD.—Heavy, very hard and strong, close-grained, dark red-brown, with thin, lighter colored sapwood.

DISTRIBUTION.—Frequent in western Vermont to the foot-hills of the Green mountains and known in the Connecticut valley as far north as Hartford.

HABITAT.—Rich woodlands of the lower altitudes.

NOTES.—The distinctive characters of this tree are well known to many Vermonters, who, as children, have become familiar with the sweet wintergreen flavor of bark and leaves. It is common in western Vermont, but reaches only the foothills of the Green mountains. Its northern limit in the Connecticut valley is in the vicinity of Norwich. Two kinds of catkins are noticeable upon the bare trees in winter; and they open on the first spring days, before most other trees have made a visible response to the sun's rays. The wood is valuable for furniture and fuel.

Yellow Birch. Gray Birch



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ½.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruiting branchlet, x ½.
8. Fruit, x 10.

BETULACEAE

Yellow Birch. Gray Birch

Betula lutea Michx. f.

HABIT.—A tree 60-80 feet high and 2-4 feet in trunk diameter; numerous slender, pendulous branches form a broad, open, rounded crown.

LEAVES.—Alternate, solitary or in pairs, simple, 3-5 inches long and one-half as broad; ovate to oblong-ovate; sharply doubly serrate; dull dark green above, yellow-green beneath; petioles short, slender, grooved, hairy; slightly aromatic.

FLOWERS.—April-May, before the leaves; monoecious; the staminate catkins 3-4 inches long, slender, pendent, purplish yellow; the pistillate catkins sessile or nearly so, erect, almost 1 inch long, greenish.

FRUIT.—Ripens in autumn; sessile or short-stalked, erect, glabrous strobiles, about 1 inch long and half as thick; scales downy on the back and edges; nut about as broad as the wing.

WINTER-BUDS.—Terminal bud absent; lateral buds about ¼ inch long, conical, acute, chestnut-brown, more or less appressed; bud-scales more or less pubescent.

BARK.—Twigs, branches and young stems smooth, very lustrous, silvery gray or light orange; becoming silvery yellow-gray as the trunk expands and breaking into strips more or less curled at the edges; old trunks becoming gray or blackish, dull, deeply and irregularly fissured into large, thin plates; somewhat aromatic, slightly bitter. Plate III.

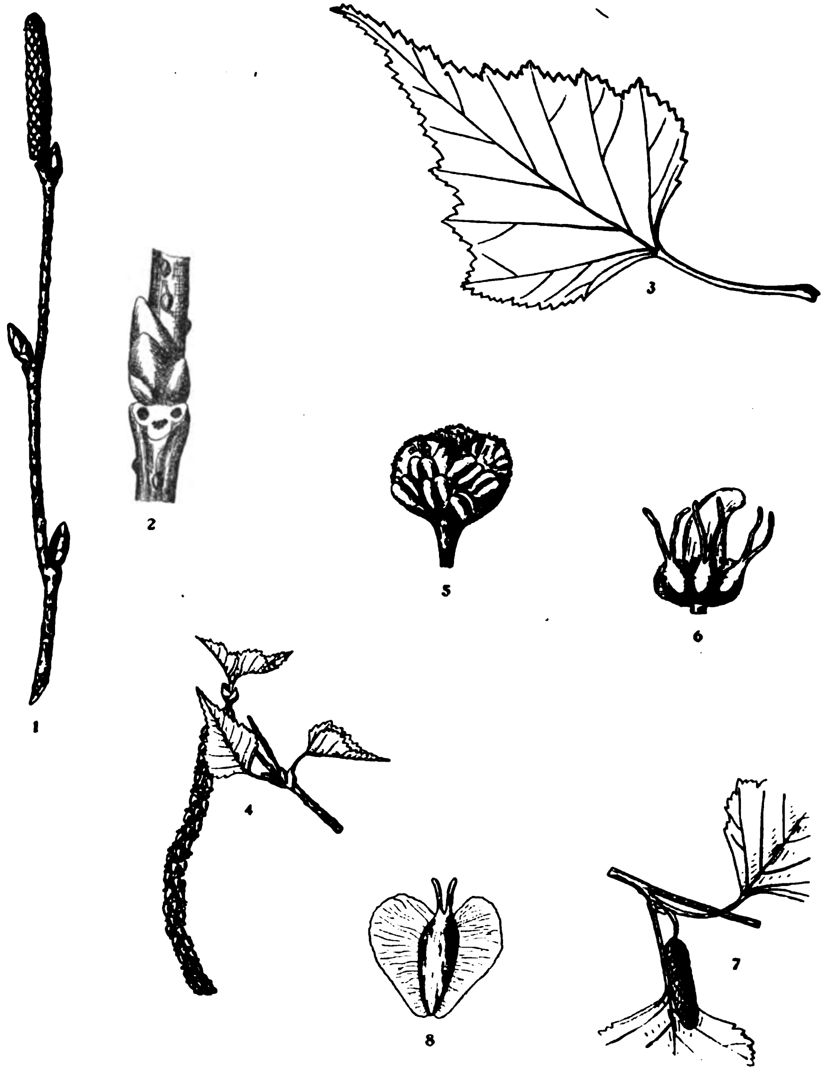
WOOD.—Heavy, very strong and hard, close-grained, light brown tinged with red, with thin, whitish sapwood. Page 227.

DISTRIBUTION.—Frequent throughout Vermont, especially on the mountain slopes up to 1,000 feet altitude.

HABITAT.—Rich, cool soils; mountain slopes; borders of swamps.

NOTES.—The polished silvery yellow bark of the mature tree marks the yellow birch almost as clearly as does the red-brown bark in the case of the preceding species. On the oldest trees in the primeval forest, however, the bark becomes a darker bronze and rough. It is common in nearly all parts of Vermont, but especially in rich, cool soils, and it extends far up the sides of our higher mountains. During the winter the little catkins remain tightly closed, but by May they lengthen into slender, drooping catkins. Yellow birch lumber is valuable for many purposes. It takes a beautiful polish, and is becoming increasingly popular for furniture and for flooring. Because of its graceful form and attractive, yellow bark, it merits more general usage for ornamental planting.

White Birch. Gray Birch. Old Field Birch



1. **Winter twig, x 1.**
2. **Portion of twig, enlarged.**
3. **Leaf, x 1.**
4. **Flowering branchlet, x ½.**
5. **Staminate flower, enlarged.**
6. **Pistillate flower, enlarged.**
7. **Fruiting branchlet, x ½.**
8. **Fruit, enlarged.**

BETULACEAE

White Birch. Gray Birch. Old Field Birch

Betula populifolia Marsh.

HABIT.—A small tree 20-30 feet high, with a slender, usually leaning trunk 6-10 inches in diameter; slender, somewhat contorted branches clothe the trunk to the ground, forming a narrow-pyramidal, open, pointed crown; commonly growing in clusters of several trunks.

LEAVES.—Alternate, solitary or in pairs, simple, 2-3 inches long and two-thirds as broad; nearly triangular to rhombic-ovate, long-pointed; coarsely doubly serrate; lustrous, dark green above, paler beneath; petioles long, slender, covered with black glands. Tremulous with the slightest breeze.

FLOWERS.—April-May, with the leaves; monoecious; the staminate catkins usually solitary, 2-4 inches long, slender, pendent, yellowish; the pistillate catkins ½-1 inch long, erect or suberect, greenish, on peduncles ½ inch long.

FRUIT.—Ripens in autumn; slender-stalked, pubescent, erect or drooping strobiles, about 1 inch long and one-third as thick; scales finely hairy; nuts slightly narrower than their wings.

WINTER-BUDS.—Terminal bud absent; lateral buds ⅛-¼ inch long, ovoid, acute, pale brown, divergent.

BARK.—Twigs green and warty-glandular, becoming smooth and red-brown; bark of trunk close, not peeling, dull chalky-white on the outer surface, with dark, triangular patches below the insertion of branches, reddish yellow on the inner, becoming nearly black and shallowly fissured at the base of old trunks.

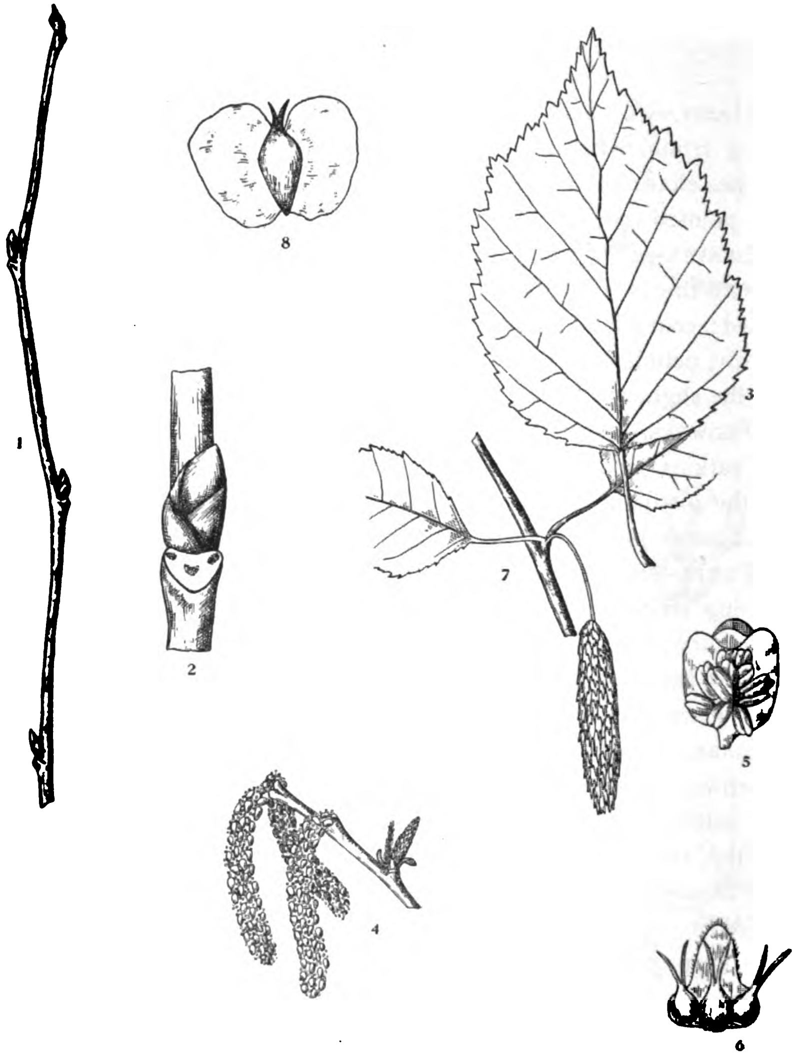
WOOD.—Light, soft, weak, close-grained, light brown, with thick, whitish sapwood.

DISTRIBUTION.—Common in the Champlain valley; frequent in the southern portion of Vermont.

HABITAT.—Poor, sandy soil; old fields; waste lands.

NOTES.—The white birch at best is but a small, short-lived tree, but it grows in such numbers that it is sure to attract attention. It never reaches sufficient size to become a valuable lumber tree, but its light elastic stem always is in demand for spools, shoe-pegs, and barrel-hoops. The white birch with its white trunk and graceful branches and light, delicate foliage is one of our most beautiful trees, but its desirability for transplanting is lessened by its short life and liability to injury from storms.

Paper Birch. Canoe Birch. White Birch



(Mich. Trees).

1. **Winter twig, x 1.**
2. **Portion of twig, enlarged.**
3. **Leaf, x 1.**
4. **Flowering branchlet, x ½.**
5. **Staminate flower, enlarged.**
6. **Pistillate flower, enlarged.**
7. **Fruiting branchlet, x ½.**
8. **Fruit, x 3½.**

BETULACEAE

Paper Birch. Canoe Birch. White Birch

Betula alba papyrifera (Marsh.) Spach. [Betula papyrifera Marsh.]

HABIT.—A tree 50-75 feet high, with a trunk diameter of 1-3 feet, forming in youth a compact, pyramidal crown of many slender branches, becoming in old age a long, branchless trunk with a broad, open crown, composed of a few large limbs ascending at an acute angle, with almost horizontal branches and a slender, flexible spray.

LEAVES.—Alternate, simple, 2-3 inches long, 1½-2 inches broad; ovate; coarsely, more or less doubly serrate; thick and firm; glabrous, dark green above, lighter beneath, covered with minute black glands; petioles stout, yellow, glandular, glabrous or pubescent.

FLOWERS.—April-May, before the leaves; monoecious; the staminate catkins clustered or in pairs, 3-4 inches long, slender, pendent, brownish; the pistillate catkins about 1½ inches long, slender, erect or spreading, greenish; styles bright red.

FRUIT.—Ripens in autumn; long-stalked, cylindrical, glabrous, drooping strobiles, about 1½ inches long; scales hairy on the margin; nut narrower than its wing.

WINTER-BUDS.—Terminal bud absent; lateral buds ¼ inch long, narrow-ovoid, acute, flattish, slightly resinous, usually divergent.

BARK.—Twigs dull red, becoming lustrous, orange-brown; bark of trunk and large limbs cream-white and lustrous on the outer surface, bright orange on the inner, separating freely into thin, papery layers, becoming furrowed and almost black near the ground. Plate III.

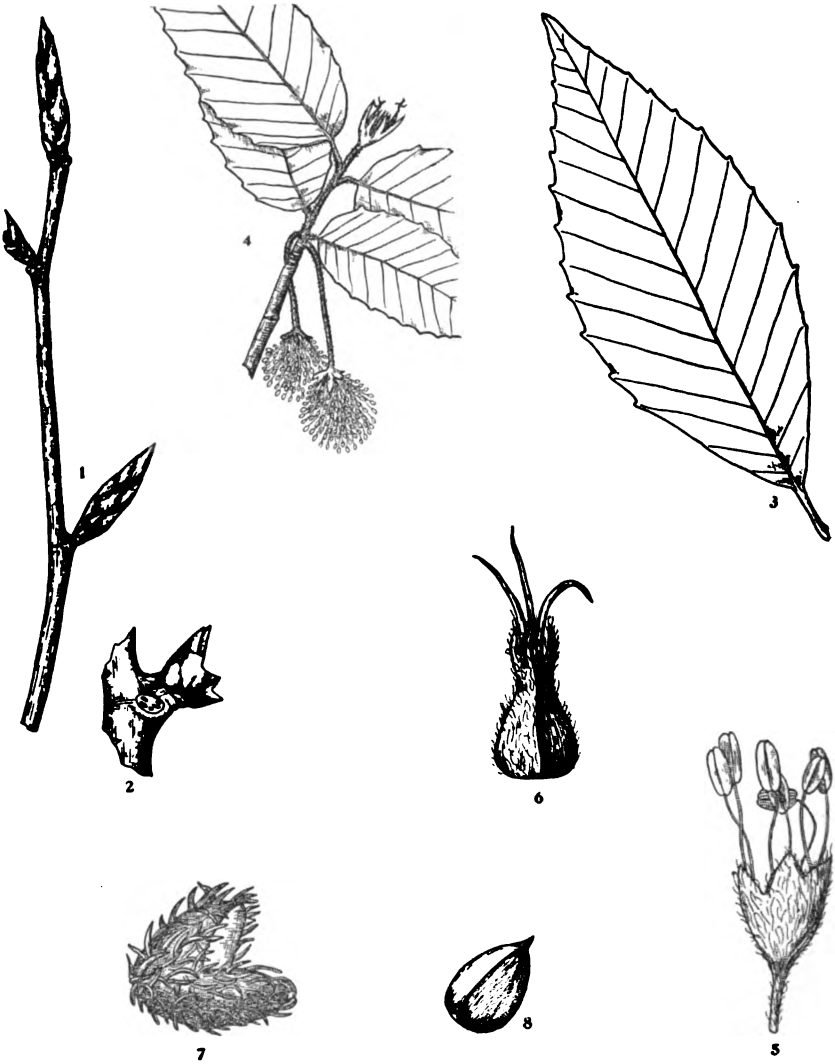
WOOD.—Light, hard, strong, tough, very close-grained, light brown tinged with red, with thick, whitish sapwood.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Prefers rich, moist hillsides; borders of streams, lakes and swamps; mountain slopes.

NOTES.—The paper birch is often intermingled with the white birch and is confused popularly with it, although careful observation reveals many characteristics by which the two may be distinguished. The paper birch is a larger tree than the white birch and more widely distributed. The two species are similar in the chalky whiteness of the bark, but that of the white birch clings closely so that it cannot be separated in large layers, whereas the peculiar character of the paper birch is the ease with which ample sheets of the beautiful corky layers may be removed.

Beech



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ½.
4. Flowering branchlet, x ¾.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Bur, opened, x 1.
8. Nut, x 1.

FAGACEAE

Beech

Fagus grandifolia Ehrh. [Fagus atropunicea (Marsh.) Sudw.]
[Fagus ferruginea Ait.] [Fagus americana Sweet]

HABIT.—A beautiful tree, rising commonly to a height of 50-75 feet, with a trunk diameter of 2-4 feet; in the forest, tall and slender, with short branches forming a narrow crown, in the open with a short, thick trunk and numerous slender, spreading branches, forming a broad, compact, rounded crown.

LEAVES.—Alternate, simple, 3-5 inches long, one-half as broad; oblong-ovate, acuminate; coarsely serrate, a vein terminating in each tooth; thin; dark blue-green above, light yellow-green and very lustrous beneath; petioles short, hairy.

FLOWERS.—May, with the leaves; monoecious; the staminate in globose heads 1 inch in diameter, on long, slender, hairy peduncles, yellow-green; calyx campanulate, 4-7-lobed, hairy; corolla 0; stamens 8-10; the pistillate on short, hairy peduncles in 2-flowered clusters surrounded by numerous awl-shaped, hairy bracts; calyx urn-shaped, 4-5-lobed; corolla 0; ovary 3-celled; styles 3.

FRUIT.—Ripens in autumn; a prickly bur borne on stout, hairy peduncles, persistent on the branch after the nuts have fallen; nuts usually 3, ¾ inch long, sharply tetrahedral, brownish; sweet and edible.

WINTER-BUDS.—Nearly 1 inch long, very slender, cylindrical, gradually taper-pointed, brownish, puberulous.

BARK.—Twigs lustrous, olive-green, finally changing through brown to ashy gray; close, smooth, steel-gray on the trunk, often mottled by darker blotches and bands. Plate IV.

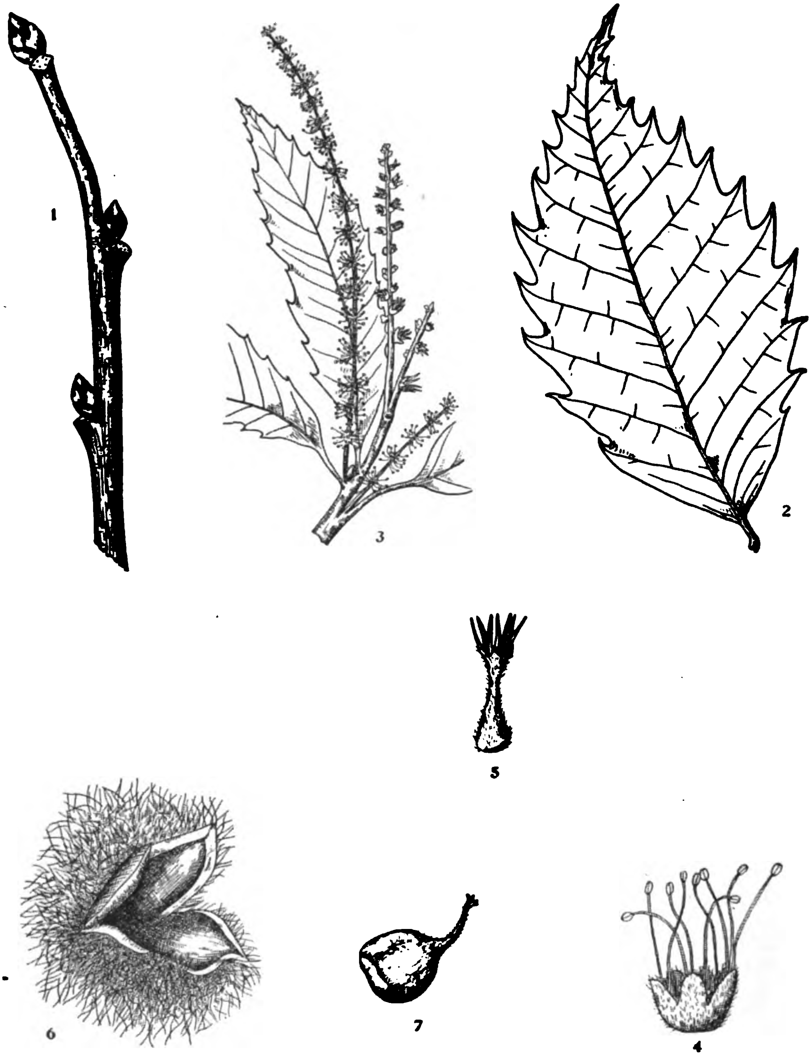
WOOD.—Hard, tough, strong, very close-grained, not durable, difficult to season, light or dark red, with thin, whitish sapwood. Page 227.

DISTRIBUTION.—Abundant throughout Vermont.

HABITAT.—Rich uplands; moist, rocky soil.

NOTES.—The beech, when growing in the forest, with its tall, graceful trunk, its smooth, gray bark and shiny leaves, is a handsome tree. It is not only one of the most common trees in Vermont, but also one of the most widely distributed in eastern North America. The drooping clusters of pollen-bearing flowers and the short, stout ovule-bearing heads open under the newly spreading leaves in early May. The burs open and the nuts fall with the first frosts of autumn.

Chestnut



(Mich. Trees).

1. **Winter twig, x 1.**
2. **Leaf, x ½.**
3. **Flowering branchlet, x ½.**
4. **Staminate flower, enlarged.**
5. **Pistillate flower, enlarged.**
6. **Prickly bur, opened, x ⅓.**
7. **Nut, x ⅓.**

FAGACEAE

Chestnut

Castanea dentata (Marsh.) Borkh. [Castanea vesca, v. americana Michx.] [Castanea sativa, v. americana Sarg.]

HABIT.—A tree 60-80 feet high, forming a short, straight trunk 2-4 feet in diameter, divided not far above the ground into several stout, horizontal limbs and forming a broad, open, rounded crown.

LEAVES.—Alternate, simple, 6-8 inches long, 2-3 inches broad; oblong-lanceolate, long-pointed at the apex; coarsely serrate with stout, incurved, glandular teeth; thin; dull yellow-green above, lighter beneath, glabrous; petioles short, stout, puberulous.

FLOWERS.—July, after the leaves; monoecious; the staminate catkins 6-8 inches long, slender, puberulous, bearing 3-7-flowered cymes of yellow-green flowers; calyx 6-cleft, pubescent; stamens 10-20; the androgynous catkins 2½-5 inches long, puberulous, bearing 2-3 prickly involucres of pistillate flowers near their base; calyx campanulate, 6-lobed; styles 6.

FRUIT.—Ripens in autumn; round, thick, prickly burs, about 2 inches in diameter, containing 1-3 nuts; nuts compressed, brownish, coated with whitish down at the apex; sweet and edible.

WINTER-BUDS.—Terminal bud absent; lateral buds ¼ inch long, ovoid, acute, brownish.

BARK.—Twigs lustrous, yellow-green, becoming olive-green and finally dark brown; old trunks gray-brown, with shallow fissures and broad, flat ridges. Plate IV.

WOOD.—Light, soft, coarse-grained, weak, easily split, very durable in contact with the soil, red-brown, with very thin, lighter colored sapwood.

DISTRIBUTION.—Frequent in the Connecticut valley as far north as Bellows Falls and in southwestern Vermont; occasional as far north as Windsor, West Rutland, Leicester, Burlington, Colchester and Stowe. Planted as far north as Franklin.

HABITAT.—Rocky woods and hillsides.

NOTES.—The chestnut probably will grow in all parts of Vermont. It is a rapid grower and lives to a great age but is subject to a disease which threatens extermination in this country. The leaves are shiny and graceful, from six to eight inches long. When they are nearly grown, long, stiff catkins of fragrant, greenish-yellow flowers appear. These bear the pollen, the ovule-bearing flowers being smaller, enclosed in bur-like scales. The nuts, two or three in a bur, ripen in October.

THE OAKS

The oaks, abundant throughout the northern hemisphere, are remarkable for their massive trunks, their thick, rugged bark and large, strong roots. They are distinguished from all other trees by their cupped fruit, but many who have seen these fruits have not noticed the small, scaly masses of flowers which produce them. The pollen-bearing flowers are found on the same tree, but are arranged in long, slender catkins consisting of a cluster of from three to twelve stamens. Some of the oaks, including the red and black, do not mature their fruit until the second year.

Oak timber is of great commercial value, being used for a variety of purposes. For strength, toughness and durability combined, it is unsurpassed.

The oak genus is a large one. Nine species and two hybrids are included in the last flora of Vermont. They are extremely difficult to tell apart and the late Doctor Pringle remarked that after 25 years of study he did not know the oaks of Vermont. This genus varies greatly and some valuable work could be done in studying its variations.

Only the tree oaks are given in the following keys.

SUMMER KEY TO THE SPECIES OF QUERCUS

a. Leaves deeply cut or lobed.

b. Leaf-lobes acute, bristle-tipped; fruit maturing in the second season.

c. Lower surface of leaves more or less pubescent; buds hoary-tomentose; bark of trunk deeply furrowed and scaly; inner bark yellow; nut ½-¾ inch long, inclosed for about one-half of its length by a deep, turbinate cup....**Q. velutina,** p. 127.

cc. Lower surface of leaves glabrous or nearly so; buds glabrous; bark of trunk smoothish or only slightly fissured; inner bark whitish or pinkish; nut about 1 inch long, inclosed only at the base by a shallow, saucer-shaped cup..**Q. rubra,** p. 125.

bb. Leaf-lobes rounded, not bristle-tipped; fruit maturing in the first season.

c. Leaves cut nearly to the midrib by a pair of deep sinuses near the middle of the leaf; branches corky-ridged; nut usually ¾-1½ inches long, deeply seated in a large, conspicuously fringed cup ....**Q. macrocarpa,** p. 117.

cc. Leaves not cut by a pair of deep sinuses; branches not corky-ridged; nut about ¾ inch long, about one-fourth inclosed by a thin, tomentose, warty cup...............**Q. alba,** p. 115.

aa. Leaves not deeply cut nor lobed.

b. Bark on branches breaking into large, papery scales which curl back; acorns on stems 1-4 inches long; tree typical of swamps. **Q. bicolor,** p. 119.

bb. Bark on branches close, not breaking into large, papery scales; acorns sessile or on stalks less than 1 inch long; trees not typical of swamps.

c. Bark of trunk thin, not deeply fissured into inverted V-shaped ridges, flaky, silvery gray or ash colored; leaves coarsely toothed ....**Q. muhlenbergii,** p. 121.

cc. Bark of trunk thick, deeply fissured into inverted V-shaped ridges, not flaky, dark red-brown to nearly black; leaves coarsely crenate ....**Q. prinus,** p. 123.

WINTER KEY TO THE SPECIES OF QUERCUS

a. Terminal buds usually about ⅛ inch long.

b. Twigs thick-tomentose; entire bud pale-pubescent; branches corky-ridged; cup of acorn conspicuously fringed at the rim, [1][1] **Q. macrocarpa,** p. 117.

bb. Twigs glabrous; buds glabrous, or only slightly or partially pubescent; branches without corky ridges; cup of acorn not conspicuously fringed at the rim.

c. Bark on branches breaking into large, papery scales which curl back; buds pilose above the middle; acorns on stems 1-4 inches long .... [1] **Q. bicolor,** p. 119.

cc. Bark on branches not breaking into large, papery scales; buds glabrous; acorns sessile or very short-stalked.

d. Buds conical, acute; bud-scales scarious on the margins; nut white-downy at the apex.... [1] **Q. muhlenbergii,** p. 121.

dd. Buds broadly ovoid, obtuse; bud-scales not scarious on the margins; nut not white-downy at the apex, [1] **Q. alba,** p. 115.

aa. Terminal buds usually about ¼ inch long.

b. Buds strictly glabrous throughout; bark of trunk smoothish or only slightly fissured, inner bark not bitter-tasting; nut inclosed only at the base by a shallow, saucer-shaped cup, [2][2] **Q. rubra,** p. 125.

bb. Buds more or less pubescent or tomentose; bark of trunk deeply furrowed and roughish, inner bark bitter-tasting; nut inclosed for about one-half of its length by a deep, cup-shaped or turbinate cup.

c. Buds hoary-tomentose, obtuse at the apex, strongly angled; inner bark of trunk yellow; acorns maturing in autumn of second season; nut ½-¾ inch long, with bitter kernel, [2] **Q. velutina,** p. 127.

cc. Buds slightly hairy, sharp-pointed, not strongly angled; inner bark of trunk not yellow; acorns maturing in autumn of first season; nut 1-1½ inches long, with sweet kernel, [1] **Q. prinus,** p. 123.

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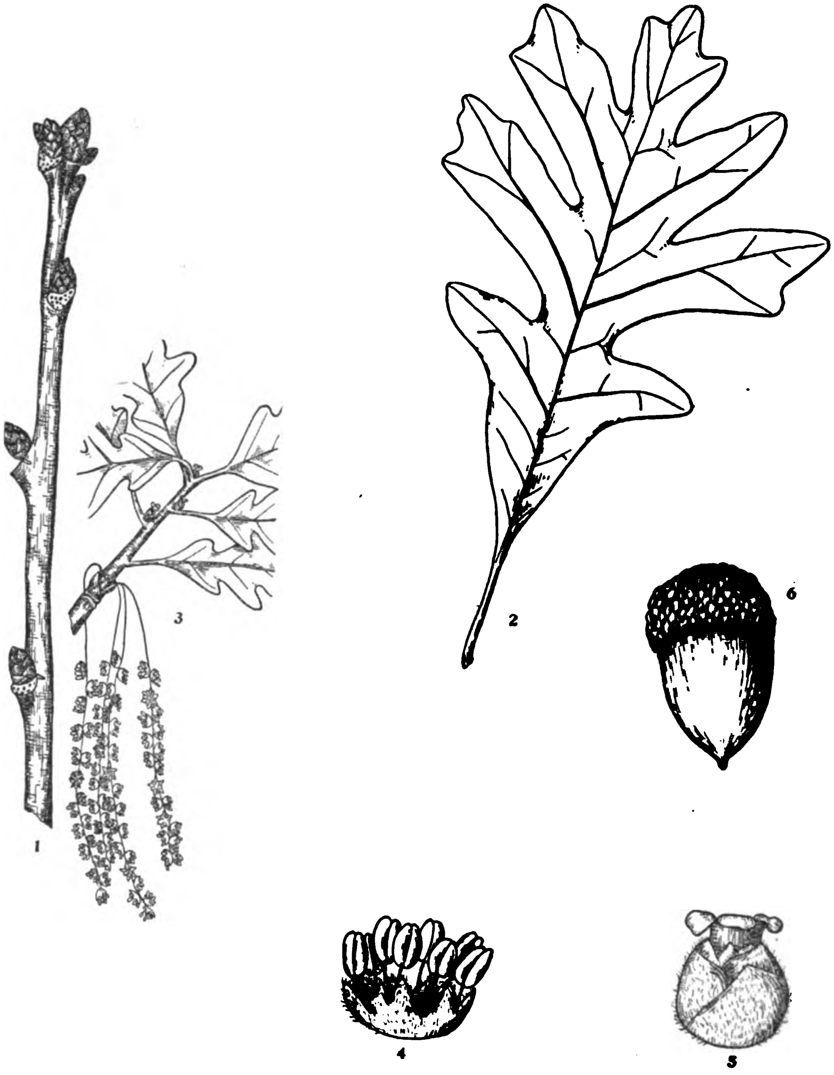
[1] [1] means that the acorns mature in the autumn of the first season, hence mature acorns will not be found on the tree, but on the ground beneath the tree.

[2] [2] means that the acorns mature in the autumn of the second season, hence immature acorns will be found on the last season's twigs, and mature acorns on the ground beneath the tree.

White Oak



(Mich. Trees).

1. **Winter twig, x 1½.**
2. **Leaf, x ½.**
3. **Flowering branchlet, x ½.**
4. **Staminate flower, enlarged.**
5. **Pistillate flower, enlarged.**
6. **Fruit, x 1.**

FAGACEAE

White Oak

Quercus alba L.

HABIT.—A large tree 50-75 feet high, with a trunk diameter of 2-4 feet; forming a short, thick trunk with stout, horizontal, far-reaching limbs, more or less gnarled and twisted in old age, and a broad, open crown.

LEAVES.—Alternate, simple, 5-9 inches long, about one-half as broad; obovate to oblong; 5-9-lobed, some with broad lobes and shallow sinuses, others with narrow lobes and deep, narrow sinuses, the lobes usually entire; thin and firm; glabrous, bright green above, pale or glaucous beneath; often persistent on the tree through the winter.

FLOWERS.—May, with the leaves; monoecious; the staminate in hairy catkins 2-3 inches long; the pistillate sessile or short-peduncled, reddish, tomentose; calyx campanulate, 6-8-lobed, yellow, hairy; corolla 0; stamens 6-8, with yellow anthers; stigmas red.

FRUIT.—Autumn of first season; sessile or short-stalked acorns; cup with small, brown-tomentose scales, inclosing one-fourth of the nut; nut oblong-ovoid, rounded at the apex, about ¾ inch long, light brown; kernel sweet and edible.

WINTER-BUDS.—Terminal bud ⅛ inch long, broadly ovoid, obtuse; scales smooth, dark red-brown.

BARK.—Twigs at first bright green, tomentose, later reddish, and finally ashy gray; thick, light gray or whitish on old trunks, shallowly fissured into broad, flat ridges. Plate IV.

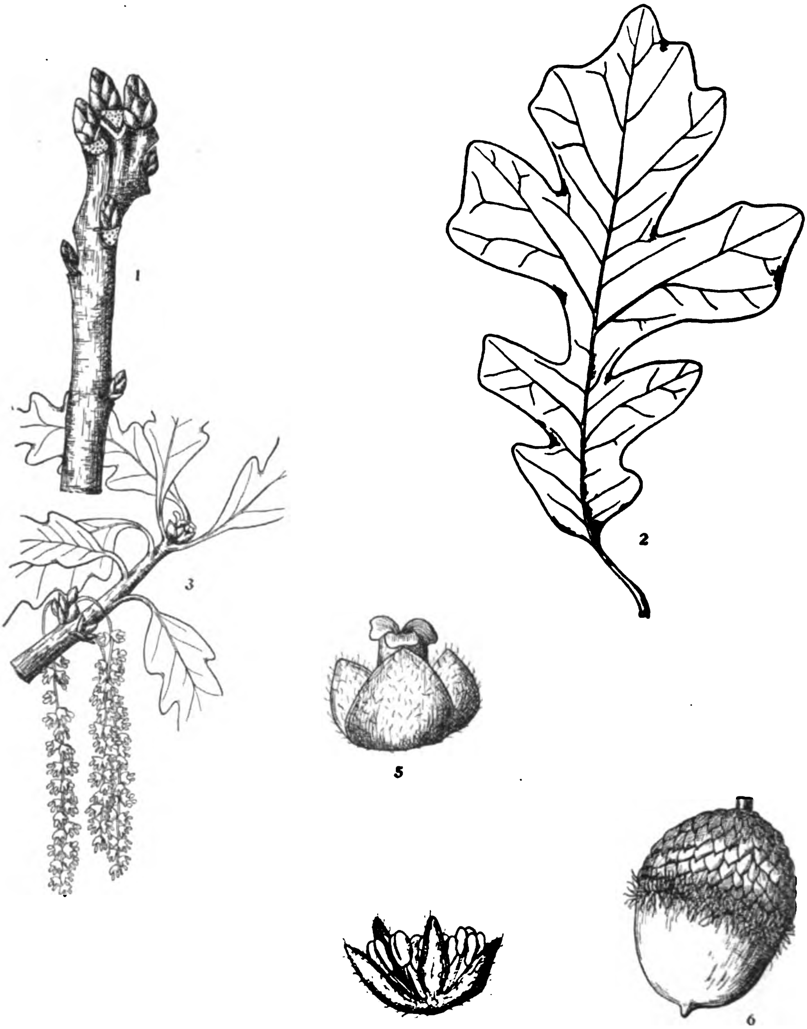
WOOD.—Very heavy, strong, hard, tough, close-grained, durable, light brown, with thin, light brown sapwood.

DISTRIBUTION.—Common west of the Green mountains; occurs sparingly in the Connecticut valley as far north as Wells River.

HABITAT.—Grows well in all but very wet soils, in all open exposures; dry woods.

NOTES.—The white oak is the most beautiful as well as the most useful of the oaks found in this part of the United States. Vermont has quite a generous supply of these trees in the Champlain valley. The tough, heavy wood of the white oak needs no recommendation. On account of the beauty of its grain and its capability of taking a high polish, it is used extensively for furniture and for interior finishing. The famous "Charter Oak" of Connecticut was of this species.

Bur Oak. Over-cup Oak. Mossy-cup Oak



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x ⅓.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate, enlarged.
6. Fruit, x 1.

FAGACEAE

Bur Oak. Over-cup Oak. Mossy-cup Oak

Quercus macrocarpa Michx.

HABIT.—A medium-sized tree 40-60 feet high, with a trunk 2-4 feet in diameter; great, spreading branches form a broad, rugged crown.

LEAVES.—Alternate, simple, 6-10 inches long and one-half as broad; obovate to oblong, wedge-shaped at the base; crenately lobed, usually cut nearly to the midrib by two opposite sinuses near the middle; thick and firm; dark green and shining above, pale pubescent beneath; petioles short, stout.

FLOWERS.—May, with the leaves; monoecious; the staminate in slender, hairy catkins 4-6 inches long; the pistillate sessile or short-stalked, reddish, tomentose; calyx 4-6-lobed, yellow-green, downy; corolla 0; stamens 4-6, with yellow anthers; stigmas bright red.

FRUIT.—Autumn of first season; sessile or short-stalked acorns; very variable in size and shape; cup typically deep, cup-shaped, tomentose, fringed at the rim, inclosing one-third or all of the nut; nut broad-ovoid, ½-1½ inches long, brownish, pubescent; kernel white, sweet and edible.

WINTER-BUDS.—Terminal bud ⅛ inch long, broadly ovoid or conical, red-brown, pale-pubescent.

BARK.—Twigs yellow-brown, thick-tomentose, becoming ash-gray or brownish; branches with corky ridges; thick and gray-brown on the trunk, deeply furrowed.

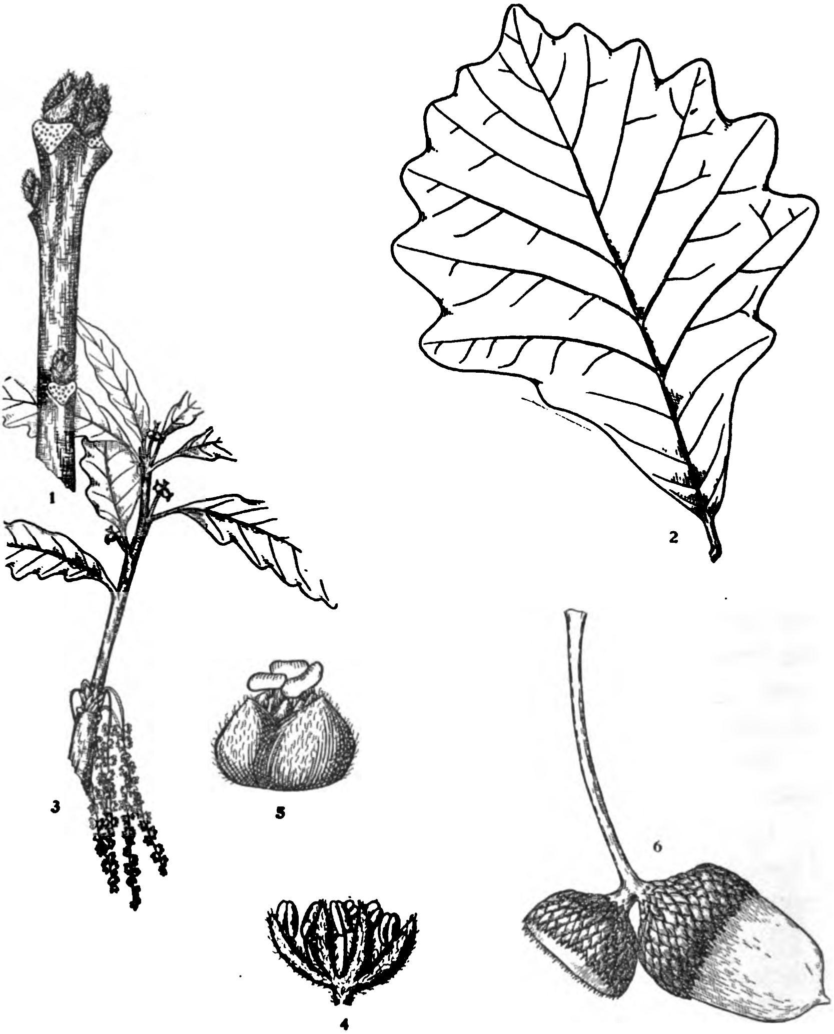
WOOD.—Heavy, hard, strong, tough, close-grained, very durable, brownish, with thin, pale sapwood.

DISTRIBUTION.—Occasional in the Champlain valley, more common in Addison county.

HABITAT.—Prefers rich, moist soil; bottom-lands.

NOTES.—The bur oak is easily recognized by its mossy cups. It is occasionally planted as an ornamental tree, but on account of its large size it is suitable only for parks and large estates. Commercially its wood is not distinguished from the white oak.

Swamp White Oak



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

FAGACEAE

Swamp White Oak

Quercus bicolor Willd. [Quercus platanoides (Lam.) Sudw.]

HABIT.—A medium-sized tree 40-60 feet high, with a trunk diameter of 2-3 feet; forming a rather open, rugged crown of tortuous, pendulous branches and short, stiff, bushy spray.

LEAVES.—Alternate, simple, 5-7 inches long, 3-5 inches broad; obovate to oblong-obovate; coarsely sinuate-crenate or shallow-lobed; thick and firm; dark green and shining above, whitish and more or less tomentose beneath; petioles stout, about ½ inch long.

FLOWERS.—May, with the leaves; monoecious; the staminate in hairy catkins 3-4 inches long; the pistillate tomentose, on long, tomentose peduncles, in few-flowered spikes; calyx deeply 5-9-lobed, yellow-green, hairy; corolla 0; stamens 5-8, with yellow anthers; stigmas bright red.

FRUIT.—Autumn of first season; acorns on pubescent stems 1-4 inches long, usually in pairs; cup cup-shaped, with scales somewhat loose (rim often fringed), inclosing one-third of the nut; nut ovoid, light brown, pubescent at the apex, about 1 inch long; kernel white, sweet, edible.

WINTER-BUDS.—Terminal bud ⅛ inch long, broadly ovoid to globose, obtuse; scales light brown, pilose above the middle.

BARK.—Twigs at first lustrous, green, becoming red-brown, finally dark brown and separating into large, papery scales which curl back; thick, gray-brown on the trunk, deeply fissured into broad, flat, scaly ridges. Plate IV.

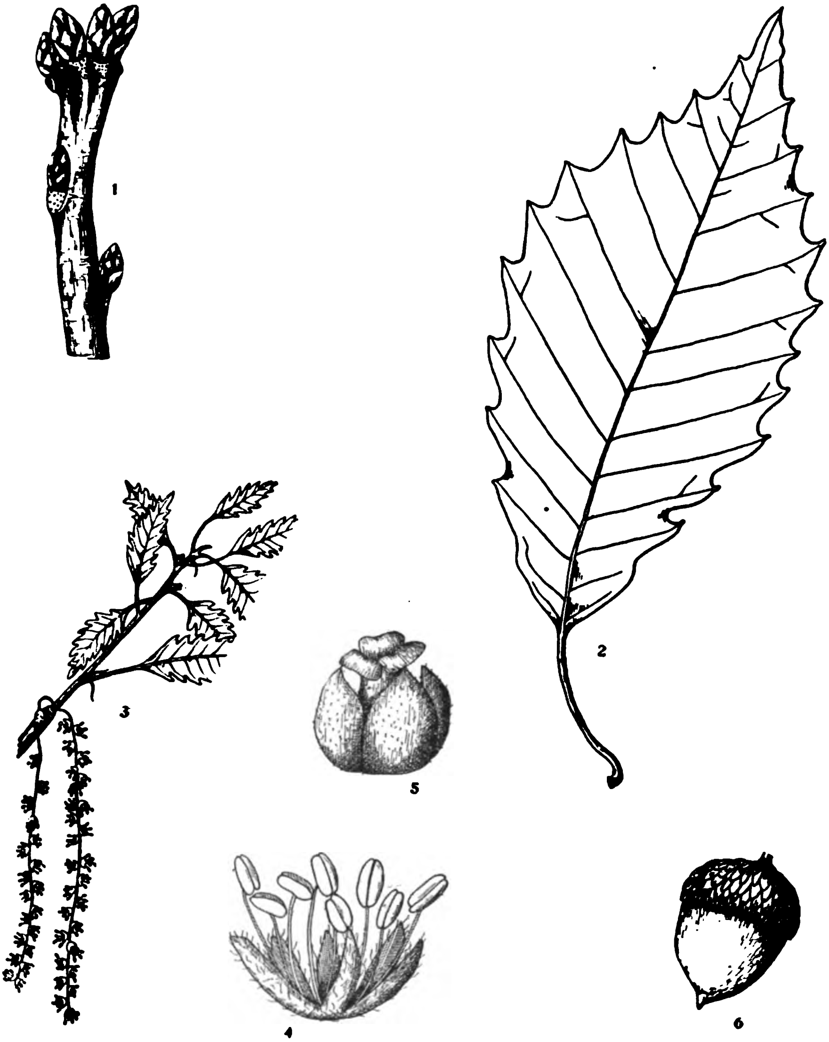
WOOD.—Heavy, hard, strong, tough, coarse-grained, light brown, with thin, indistinguishable sapwood.

DISTRIBUTION.—Frequent in the Champlain valley, especially about Lake Champlain.

HABITAT.—Prefers moist, rich soil bordering swamps and along streams.

NOTES.—In beauty and variety of grain this tree nearly equals the white oak and its wood is valuable for similar purposes. As its name suggests it grows in low, moist soil. Unfortunately the swamp oak is not found in Vermont except along the intervales of Lake Champlain and its tributaries. Here it is quite abundant and its majestic size and symmetrical, rounded top make it a conspicuous and beautiful tree. It is more easily identified than many of the oaks because of the scaly bark, the leaves downy on the lower surface and the long, downy stalks of the acorns.

Yellow Oak. Chestnut Oak



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

FAGACEAE

Yellow Oak. Chestnut Oak

Quercus muhlenbergii Engelm. [Quercus acuminata (Michx.) Houba]

HABIT.—A small to medium-sized tree 30-40 feet high, with a trunk diameter of 1-2 feet; erect, somewhat short branches form a narrow, rounded crown.

LEAVES.—Alternate, simple, 4-7 inches long, 1-4 inches broad; oblong-lanceolate to obovate; coarsely toothed; thick and firm; lustrous, yellow-green above, pale-pubescent beneath; petioles slender, about 1 inch long.

FLOWERS.—May, with the leaves; monoecious; the staminate in hairy catkins 3-4 inches long; the pistillate sessile or in short spikes, hoary-tomentose; calyx campanulate, 5-8-lobed, yellow, hairy; corolla 0; stamens 5-8, with yellow anthers; stigmas red.

FRUIT.—Autumn of first season; sessile or short-stalked acorns; cup with small scales, hoary-tomentose, inclosing one-half of the nut; nut ovoid, about ¾ inch long, light brown; kernel sweet, sometimes edible.

WINTER-BUDS.—Terminal bud ⅛ inch long, conical, acute; scales chestnut-brown, scarious on the margin.

BARK.—Twigs greenish at first, becoming gray-brown, finally gray or brown; thin, silvery gray or ash colored and flaky on the trunk.

WOOD.—Heavy, very hard, strong, close-grained, durable, dark brown, with thin, pale brown sapwood.

DISTRIBUTION.—Rare; reported from Gardiner's island in Lake Champlain, Malletts Head, Ferrisburg and Colchester.

HABITAT.—Dry limestone hillsides; rocky river-banks and lake-shores.

NOTES.—This oak is a very beautiful tree and is well adapted for use in parks and on lawns on account of its handsome foliage.

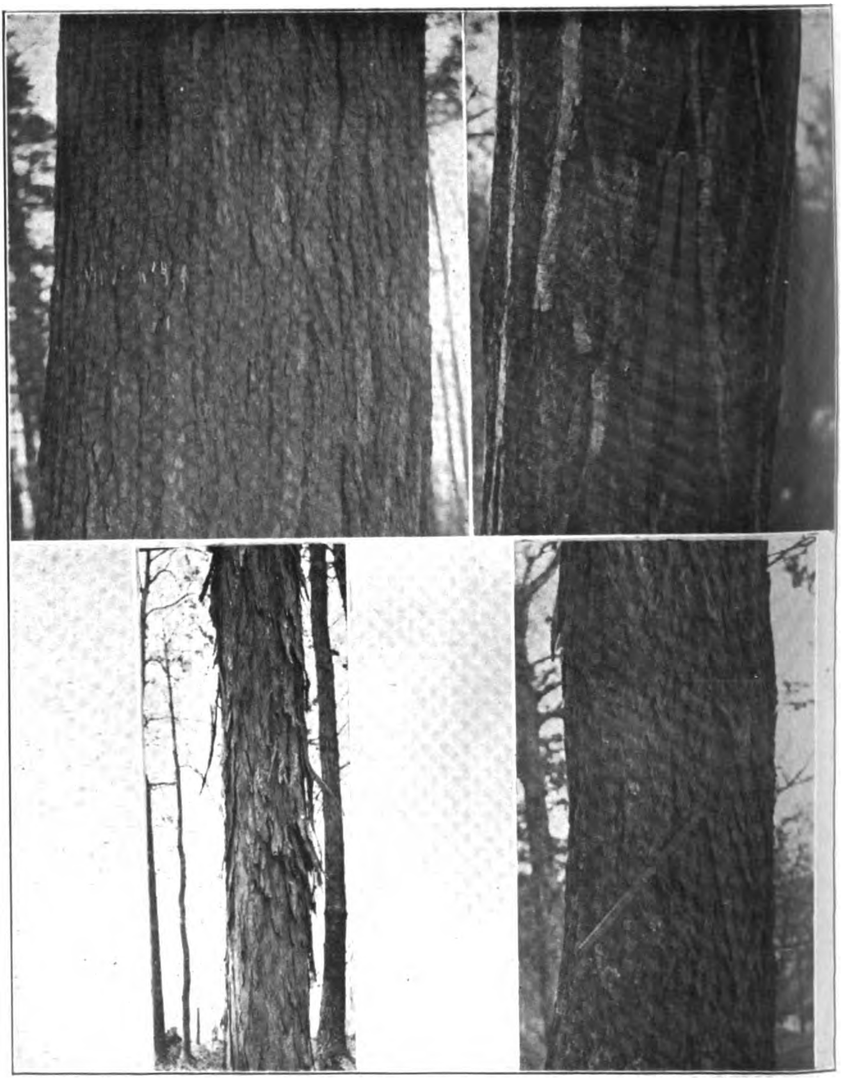


PLATE II.

Hemlock Butternut

Shellbark Hickory Pignut

FAGACEAE

Chestnut Oak

Quercus prinus L.

HABIT.—A medium-sized tree 30-50 feet high, with a trunk diameter of 1-2 feet; usually dividing near the ground into a few large branches and forming a broad, open, rather irregular crown.

LEAVES.—Alternate, simple, 6-8 inches long and one-third to one-half as broad; lanceolate to obovate; coarsely crenate; thick and firm, almost leathery; glabrous, dark green above, paler and finely pubescent beneath; petioles ½-1 inch long.

FLOWERS.—May, with the leaves; monoecious; the staminate in hairy catkins 2-2½ inches long; the pistillate in short spikes on stout, pubescent peduncles; calyx deeply 7-9-lobed, pale yellow, pilose; corolla 0; stamens 7-9, with yellow anthers; stigmas dark red.

FRUIT.—Autumn of first season; short-stalked acorns; cup thin, deep, turbinate, inclosing one-half or less of the nut; scales small, thin-tipped, with thickened bases, hoary-pubescent; nut ovoid to oblong-ovoid, 1-1½ inches long, light brown; kernel sweet, but insipid.

WINTER-BUDS.—Terminal bud ¼-⅜ inch long, ovoid, sharp-pointed; scales light brown, slightly hairy toward the apex and on the margin.

BARK.—Twigs greenish, becoming orange and brown, with somewhat bitter taste; thick, dark red-brown to nearly black on old trunks, deeply fissured into thick, roughish ridges (a section through one of the ridges would resemble an inverted letter V).

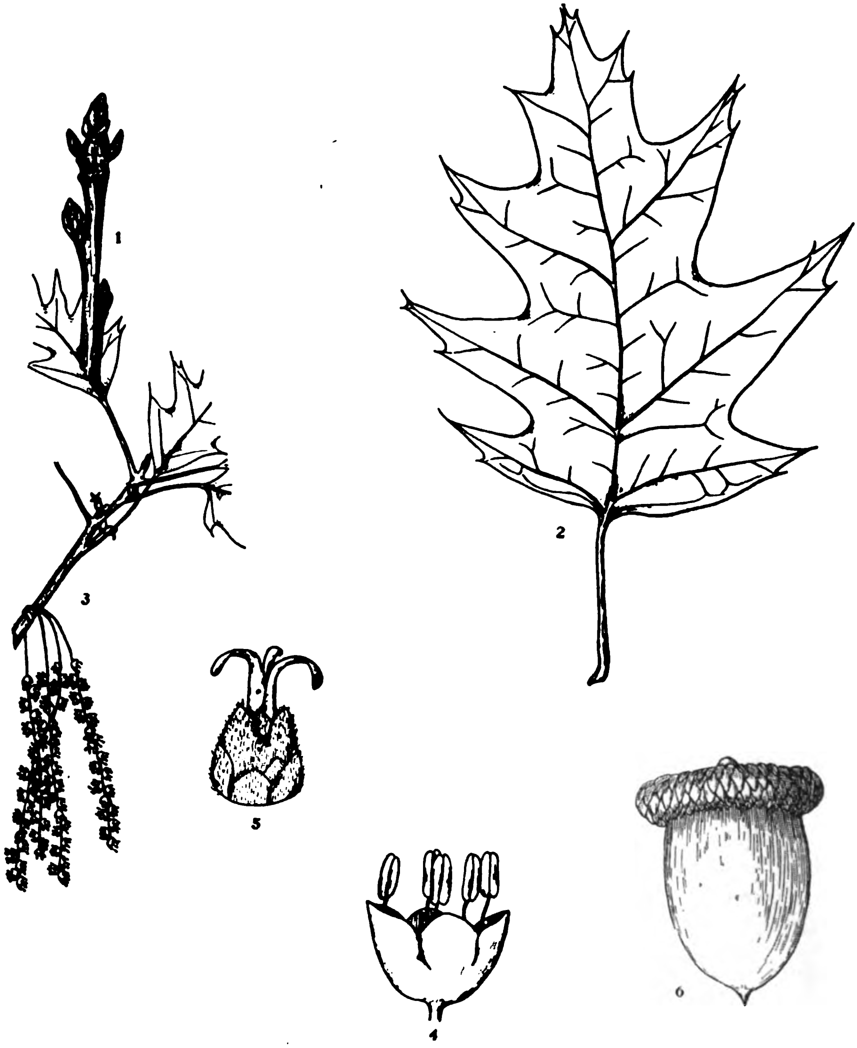
WOOD.—Heavy, hard, strong, tough, close-grained, dark brown, with thin, lighter colored sapwood.

DISTRIBUTION.—Frequent throughout the western part of Vermont from Charlotte to Pownal; abundant on Snake mountain at an altitude of 1,300 feet and on the western slopes of the Green mountains, especially in Addison county.

HABITAT.—Dry, rocky hillsides.

NOTES.—The popular name of this oak is suggested by the marked resemblance of its leaves to those of the chestnut. It is one of the common oaks from Massachusetts and New York southward, forming a large tree on rocky hillsides, often associated with the chestnut. The line of its northern distribution passes through the Champlain valley. It occurs probably also in the southeastern part of Vermont. The acorns are large, one inch or more in length. The wood is hard and tough and is used frequently for railroad ties.

Red Oak



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

FAGACEAE

Red Oak

Quercus rubra L.

HABIT.—A large tree 70-80 feet high, with a trunk diameter of 2-4 feet; forming a broad, rounded crown of a few large, wide-spreading branches and slender branchlets.

LEAVES.—Alternate, simple, 5-9 inches long, 4-6 inches broad; oval to obovate; 5-11-lobed with coarse-toothed, bristle-tipped lobes tapering from broad bases and wide, oblique, rounded sinuses; thin and firm; dull dark green above, paler beneath; petioles stout, 1-2 inches long.

FLOWERS.—May, when the leaves are half grown; monoecious; the staminate in hairy catkins 4-5 inches long; the pistillate on short, glabrous peduncles; calyx 4-5-lobed, greenish; corolla 0; stamens 4-5, with yellow anthers; stigmas long, spreading, bright green.

FRUIT.—Autumn of second season; sessile or short-stalked acorns; cup shallow, saucer-shaped, inclosing only the base of the nut; scales closely appressed, more or less glossy, puberulous, bright red-brown; nut oblong-ovoid with a broad base, about 1 inch long, red-brown; kernel white, very bitter.

WINTER-BUDS.—Terminal bud ¼ inch long, ovoid, acute, light brown, smooth.

BARK.—Twigs lustrous, green, becoming reddish, finally dark brown; young trunks smooth, gray-brown; old trunks darker, shallowly fissured into thin, firm, broad ridges; inner bark light red, not bitter. Plate V.

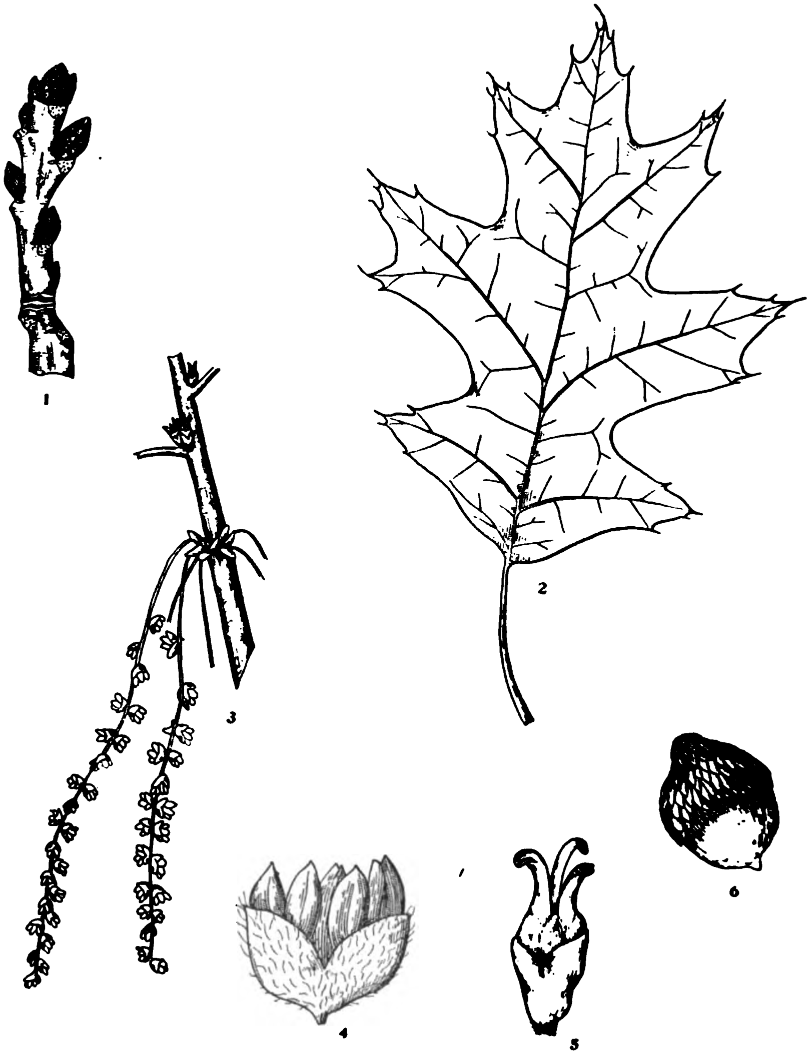
WOOD.—Heavy, hard, strong, coarse-grained, light red-brown, with thin, darker colored sapwood. Page 230.

DISTRIBUTION.—Common throughout Vermont at altitudes below 1,000 feet.

HABITAT.—Grows well in all well-drained soils; rich and poor soil.

NOTES.—The red oak is the most northern of all the oaks, ranging from Nova Scotia to Tennessee. It is distributed generally through the Champlain and lower Connecticut valleys where it is the most common oak. It is less common in the northern part of the Connecticut valley. The flowers appear in May but the sessile, shallow-cupped acorns do not ripen until the second autumn. The wood is lighter in weight and more brittle than that of the white oak but when quartered shows a beautiful grain and is used for furniture. It is valued also for bridge posts where there is to be exposure to water. The wood dries out slowly and is inferior as fuel.

Quercitron. Yellow-barked Oak. Black Oak



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

FAGACEAE

Quercitron. Yellow-barked Oak. Black Oak

Quercus velutina Lam.

HABIT.—A medium-sized tree 50-60 feet high and 1-3 feet in trunk diameter; slender branches and stout branchlets form a wide-spreading, rounded crown.

LEAVES.—Alternate, simple, 5-10 inches long, 3-8 inches broad; ovate to oblong; usually 7-lobed, some with shallow sinuses and broad, rounded, mucronate lobes, others with wide, rounded sinuses extending half-way to the midrib or farther and narrow-oblong or triangular, bristle-tipped lobes, the lobes more or less coarse-toothed, each tooth bristle-tipped; thick and leathery; dark green and shining above, pale and more or less pubescent beneath; petioles stout, yellow, 3-6 inches long.

FLOWERS.—May, when the leaves are half grown; monoecious; the staminate in pubescent catkins 4-6 inches long; the pistillate reddish, on short, tomentose peduncles; calyx acutely 3-4-lobed, reddish, hairy; corolla 0; stamens usually 4-5, with acute, yellow anthers; stigmas 3, divergent, red.

FRUIT.—Autumn of second season; sessile or short-stalked acorns; cup cup-shaped or turbinate, inclosing about one-half of the nut; scales thin, light brown, hoary; nut ovoid, ½-¾ inch long, red-brown, often pubescent; kernel yellow, bitter.

WINTER-BUDS.—Terminal bud ¼ inch long, ovoid to conical, obtuse, strongly angled, hoary-tomentose.

BARK.—Twigs at first scurfy-pubescent, later glabrous, red-brown, finally mottled gray; thick and nearly black on old trunks, deeply furrowed and scaly; inner bark thick, yellow, very bitter. Plate V.

WOOD.—Heavy, hard, strong, coarse-grained, bright red-brown, with thin, paler sapwood.

DISTRIBUTION.—Frequent in western Vermont and in the Connecticut valley as far north as Bellows Falls.

HABITAT.—Dry, light soil; poor soils.

NOTES.—The quercitron or yellow-barked oak is a southern species which reaches its northern limit in Vermont. It is not uncommon in light, dry soils in the Champlain valley and it occurs also in the southern part of the Connecticut valley. The two common and apparently incompatible names, yellow oak and black oak, arise from the diverse colors of the inner bark and the outer bark. The former, which is used in tanning, is yellow, while the later is very dark. The leaves are rather large, dark, shiny green with yellowish petioles.

THE ELMS

We are fortunate in having in Vermont all of the elms of the eastern United States except one small southern species. The tiny greenish flowers have no petals, but gracefully fringe the bare trees with their long slender stamens in early spring before the appearance of the leaves. The fruits are supplied with a disk-like membranous wing. The leaves of all the elms have a peculiar oblique base, full and rounded upon one side, sharply wedge-shaped on the other.

Introduced species.—The English elm occasionally has been planted as a shade tree, although for such purposes it is less stately than our common white elm. Two European varieties have been more used for ornamental plantings, though each of them is curious rather than ornamental. These are the corky variety of the English elm, and the Camperdown or weeping elm, which is a variety of the Scotch elm. The young branches of the former are covered with conspicuous corky outgrowths, similar to those of the native cork elm, but more strongly developed. The American cork elm is distinguished from the English elm by its more downy bud-scales and by the production of flowers in elongated clusters (racemes), whereas those of the English elm are in close clusters. Other differences will be detected readily by those having occasion to compare the two trees. The weeping elm usually is reverse-grafted on an upright stock, leading to a peculiar umbrella-like development.

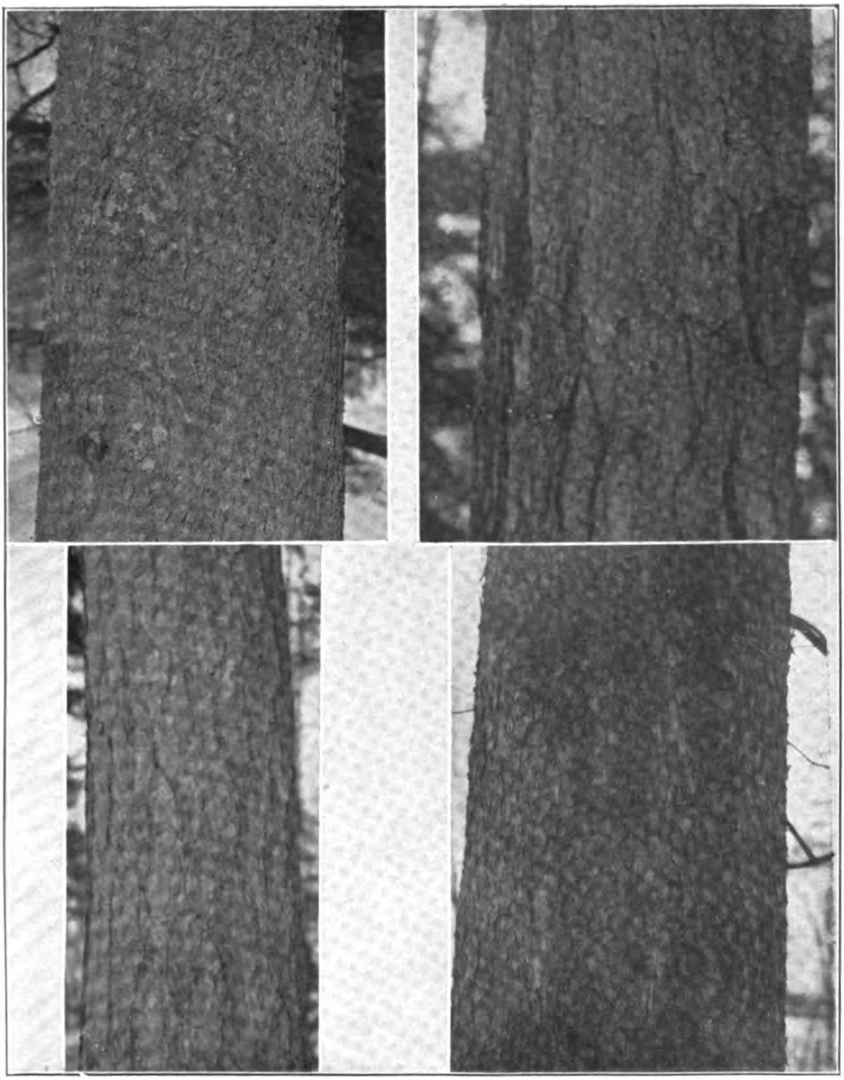


Plate I.

White Pine **Pitch Pine**

Red Pine **Tamarack**

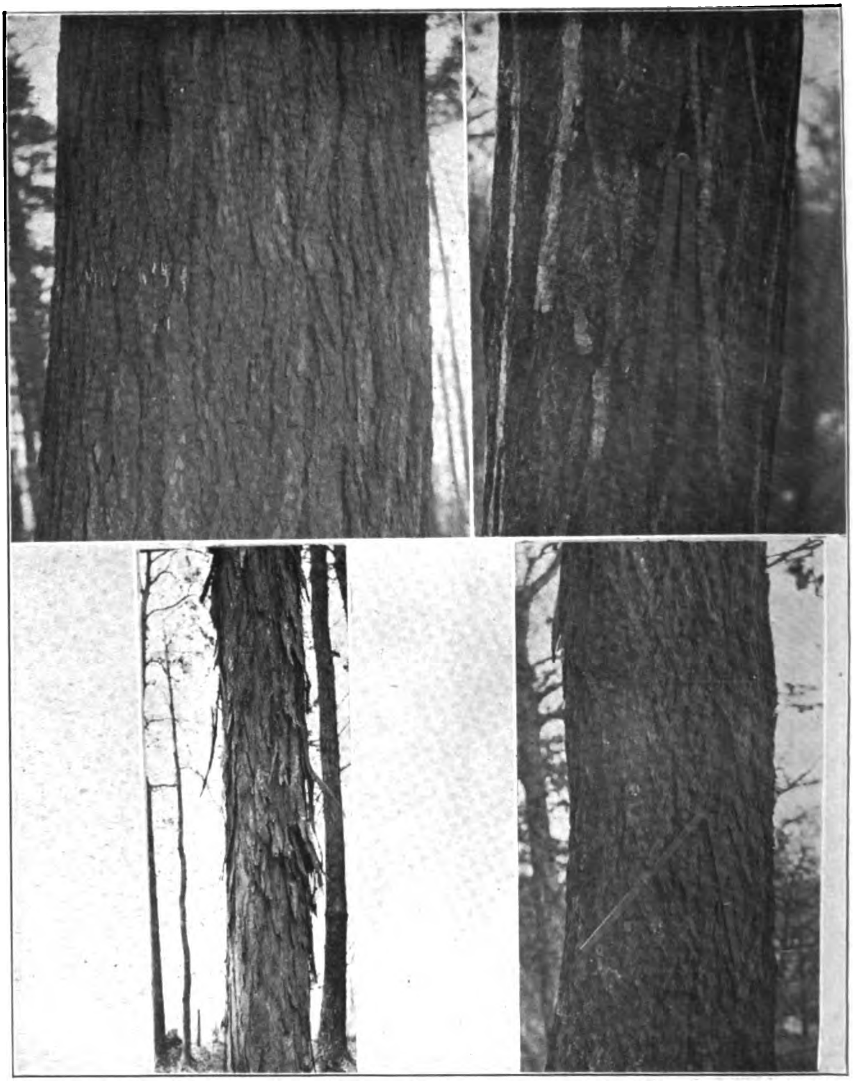


PLATE II.

Hemlock **Butternut**

Shellbark Hickory **Pignut**

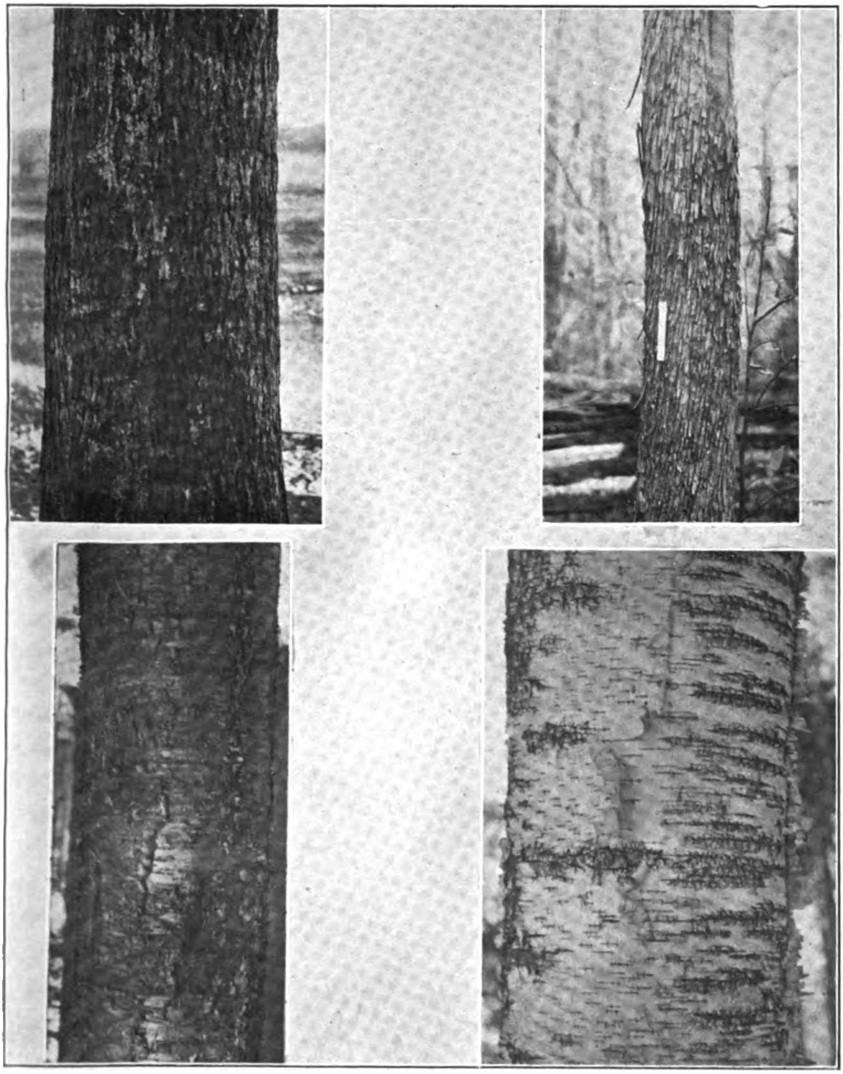


Plate III.

Bitternut **Hornbeam**

Yellow Birch **White Birch**

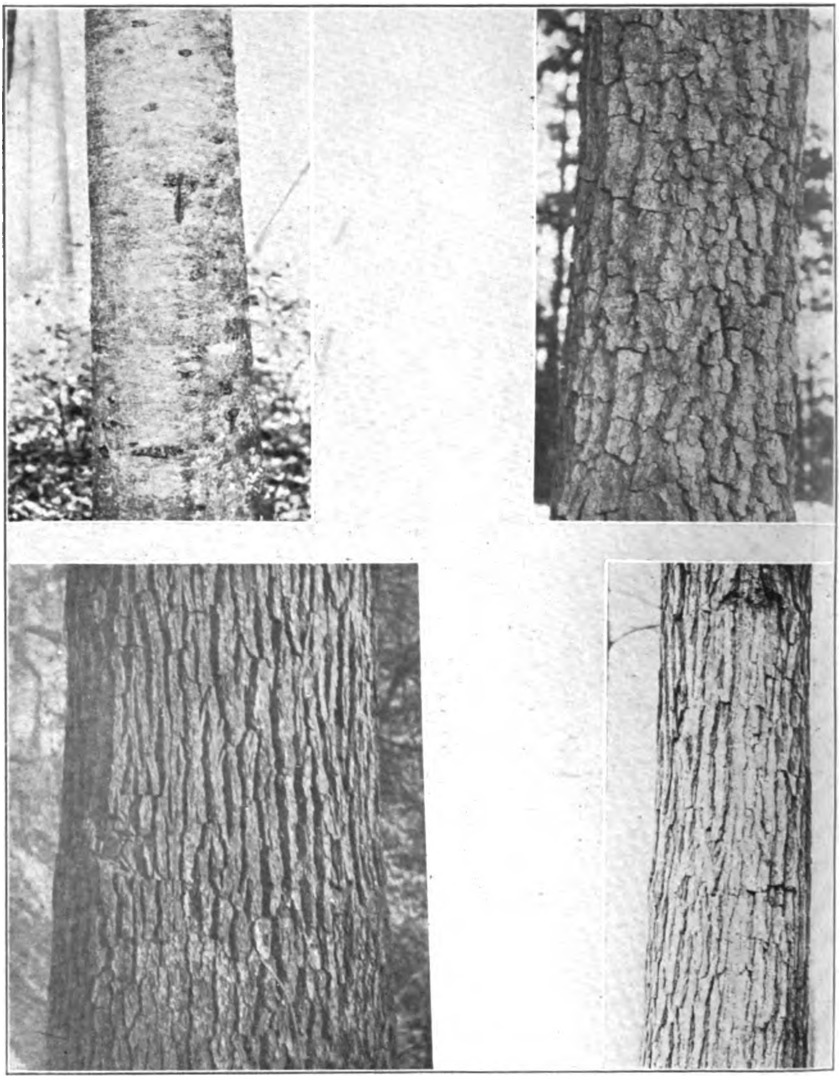


PLATE IV.

Beech Chestnut

White Oak Swamp White Oak

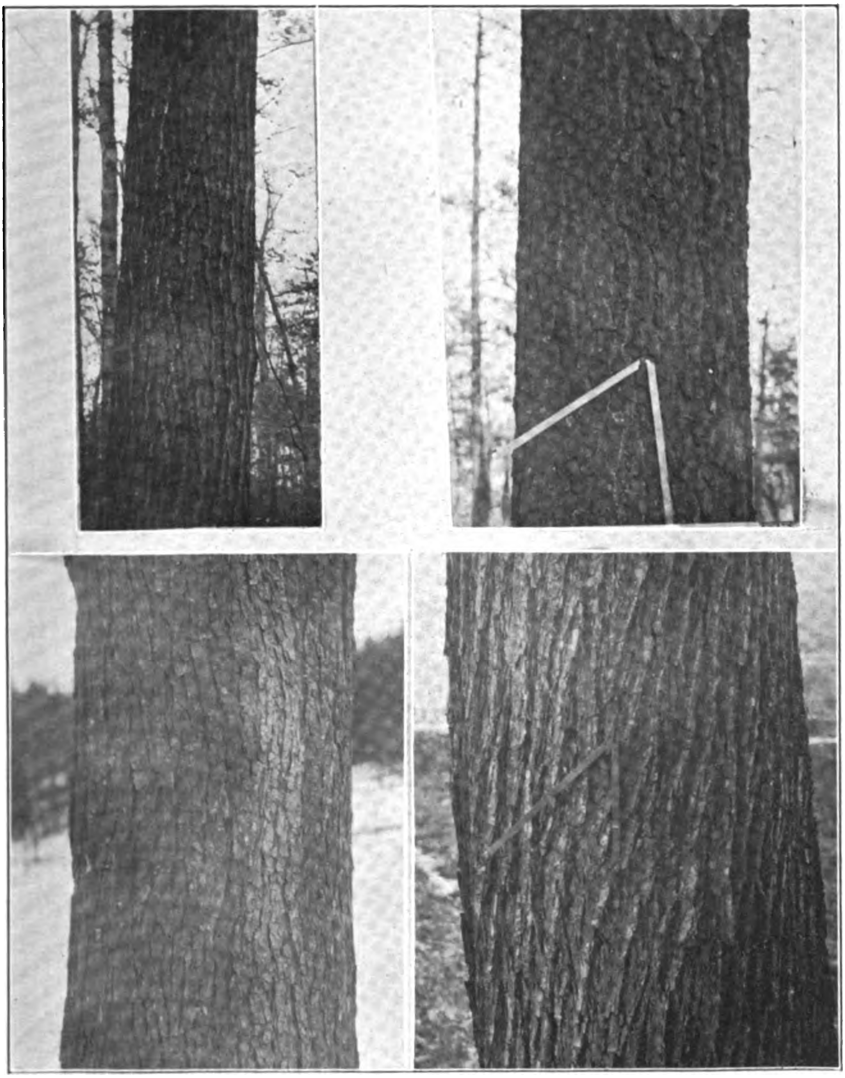


Plate V.

Red Oak — Black Oak

Slippery Elm — American Elm

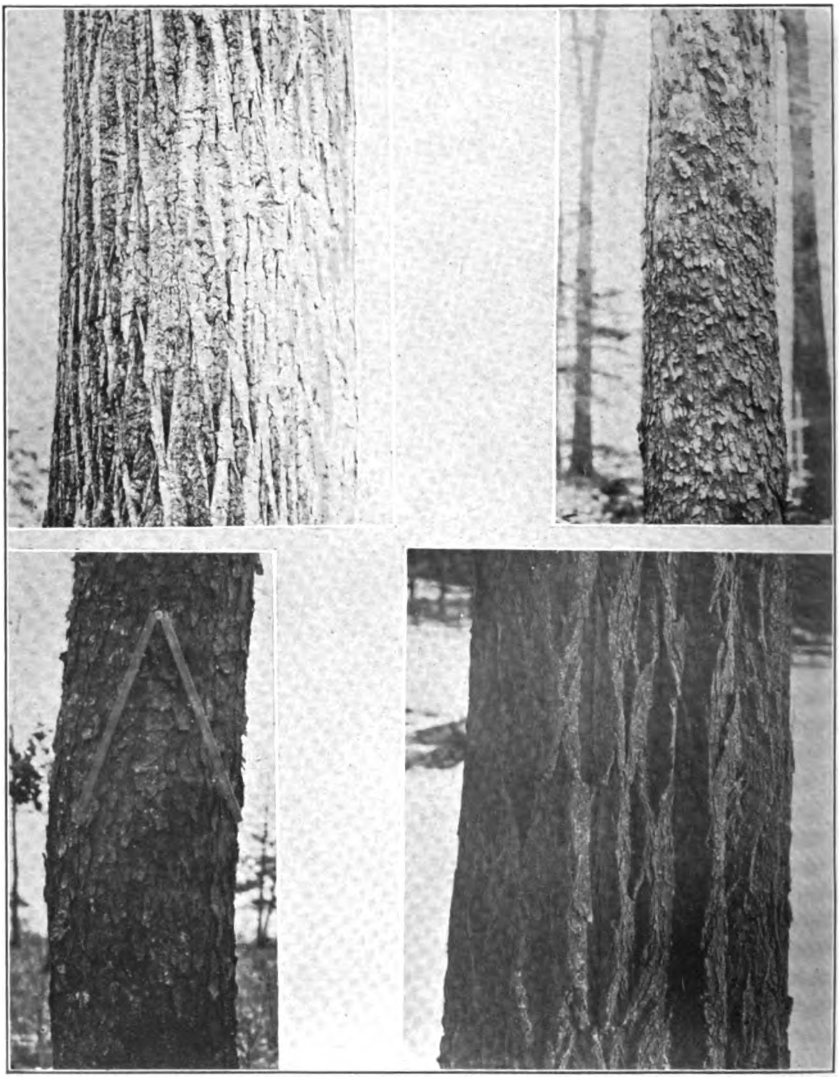


PLATE VI.

Tulip Poplar   Sycamore

Black Cherry   Black Locust

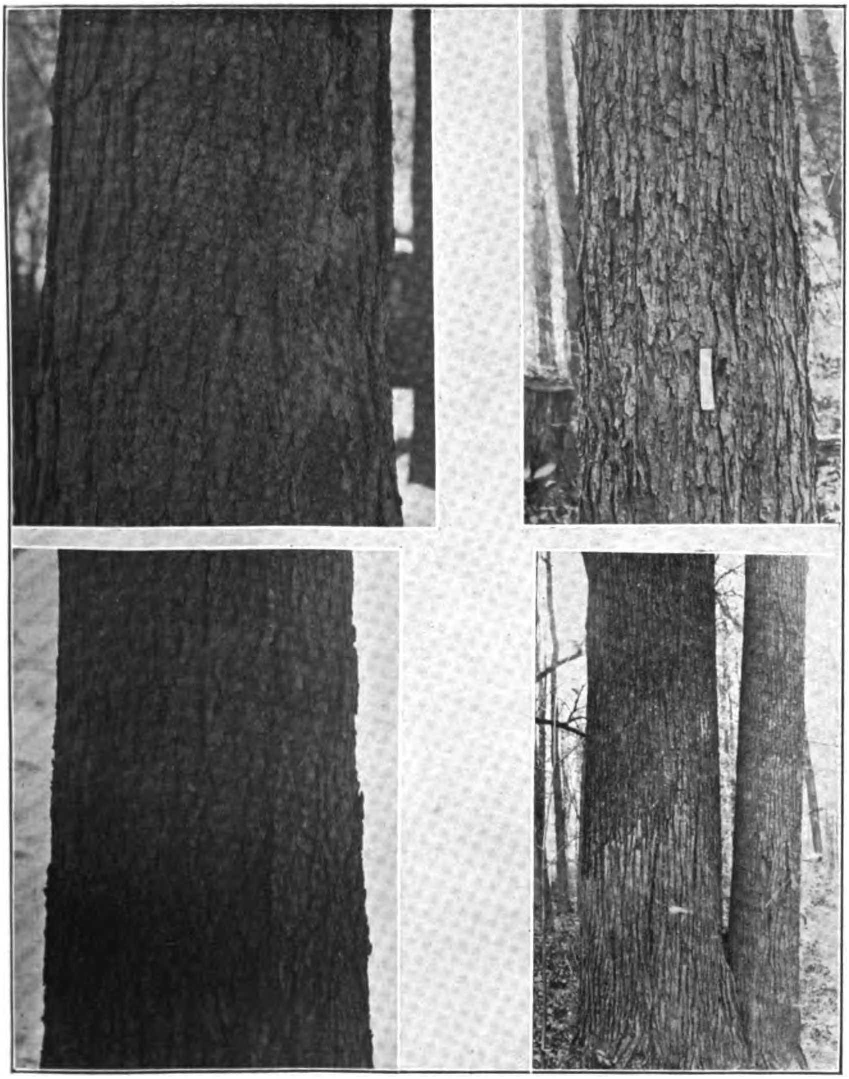


PLATE VII.

Sugar Maple **Silver Maple**

Red Maple **Basswood**

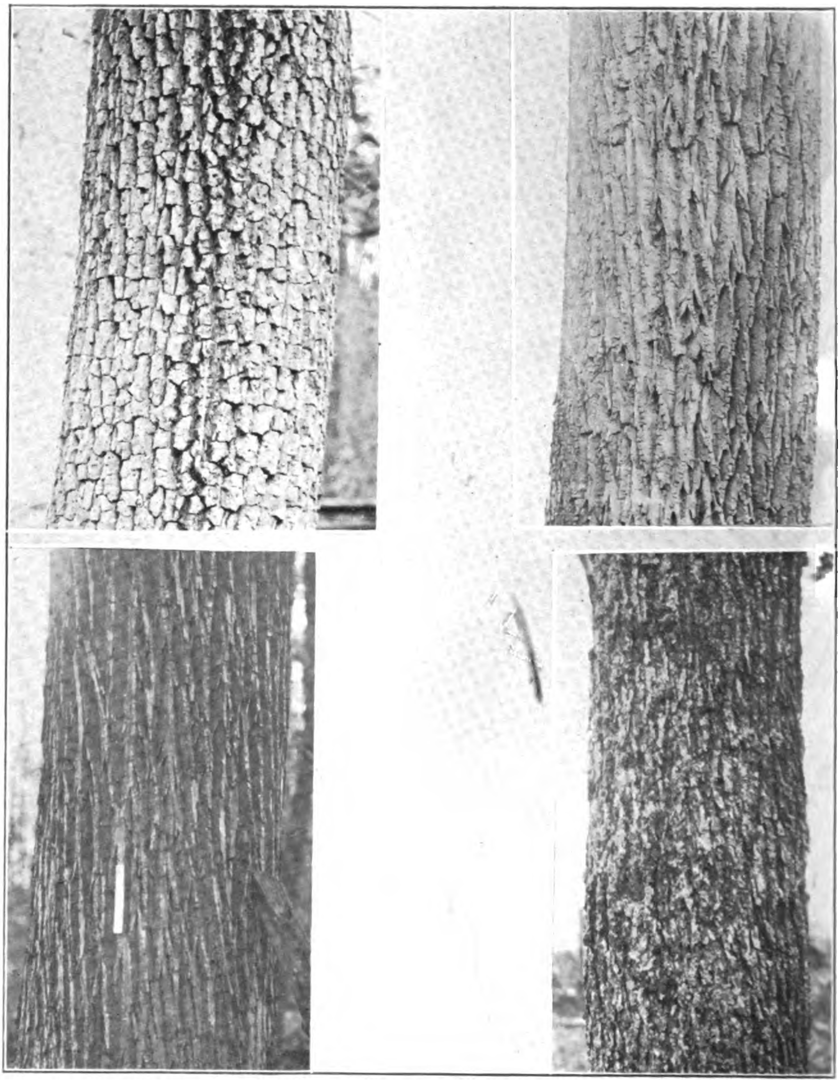


Plate VIII.

Black Gum

Red Ash

White Ash

Black Ash

SUMMER KEY TO THE SPECIES OF ULMUS

a. Leaves essentially smooth on both sides; branches often with corky, wing-like ridges; lowermost branches usually short and strongly drooping; main trunk usually continuous into the crown without dividing, giving to the tree a narrow-oblong outline, **U. racemosa,** p. 135.

aa. Leaves usually rough on one or on both sides; branches without corky ridges; lowermost branches not short, not strongly drooping; main trunk usually dividing into several large limbs, giving to the tree a more or less vase-shaped outline.

b. Leaves usually rough above, but smooth beneath, with petioles glabrous; bark of trunk gray, deeply fissured into broad, scaly ridges; inner bark not mucilaginous.... **U. americana,** p. 133.

bb. Leaves usually rough both sides, with petioles hairy; bark of trunk dark red-brown, shallowly fissured into large, loose plates; inner bark mucilaginous .... **U. fulva,** p. 131.

WINTER KEY TO THE SPECIES OF ULMUS

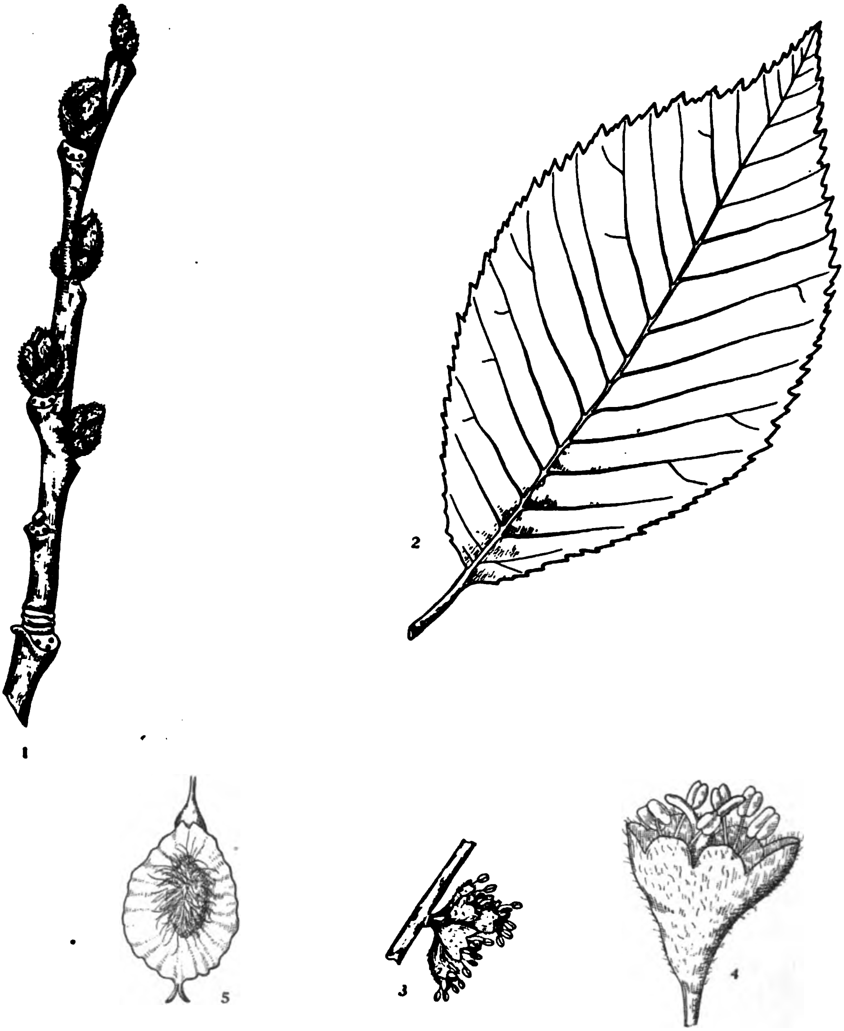
a. Buds conspicuously rusty-tomentose; twigs more or less pubescent; inner bark very mucilaginous when chewed.... **U. fulva,** p. 131.

aa. Buds not conspicuously rusty-tomentose; twigs glabrous; inner bark not mucilaginous.

b. Bundle-scars usually 3; buds 1/8 inch long, glabrous; twigs without corky ridges; outline of tree vase-shaped, **U. americana,** p. 133.

bb. Bundle-scars usually 4-6 in a curved line; buds 1/4 inch long, somewhat pilose; twigs often with corky ridges; outline of tree narrow-oblong .... **U. racemosa,** p. 135.

Slippery Elm. Red Elm



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x 1.
3. Flowering branchlet, x 1.
4. Perfect flower, enlarged.
5. Fruit, x 1.

URTICACEAE

Slippery Elm. Red Elm

Ulmus fulva Michx. [Ulmus pubescens Walt.]

HABIT.—A medium-sized tree 40-60 feet high, with a short trunk 1-2 feet in diameter; spreading branches form a broad, open, flat-topped crown.

LEAVES.—Alternate, simple, 4-7 inches long, about one-half as broad; ovate-oblong; coarsely doubly serrate; thick and firm; dark green and rough above, paler and somewhat rough beneath; petioles short, stout, hairy.

FLOWERS.—April, before the leaves; mostly perfect; borne on short pedicels in crowded fascicles; calyx campanulate, 5-9-lobed, green, hairy; corolla 0; stamens 5-9, with dark red anthers; stigmas 2, reddish purple.

FRUIT.—May; semi-orbicular, 1-seeded samaras, short-stalked in dense clusters; seed cavity brown-tomentose; wings smooth, nearly ¾ inch long.

WINTER-BUDS.—Terminal bud absent; lateral buds ovoid, obtuse, dark brown, rusty-tomentose, ¼ inch long.

BARK.—Twigs at first bright green and pubescent, becoming light to dark brown or grayish; thick on old trunks, dark red-brown, shallowly fissured into large, loose plates; inner bark mucilaginous. Plate V.

WOOD.—Heavy, hard, strong, very close-grained, durable, easy to split while green, dark red-brown, with thin, lighter colored sapwood.

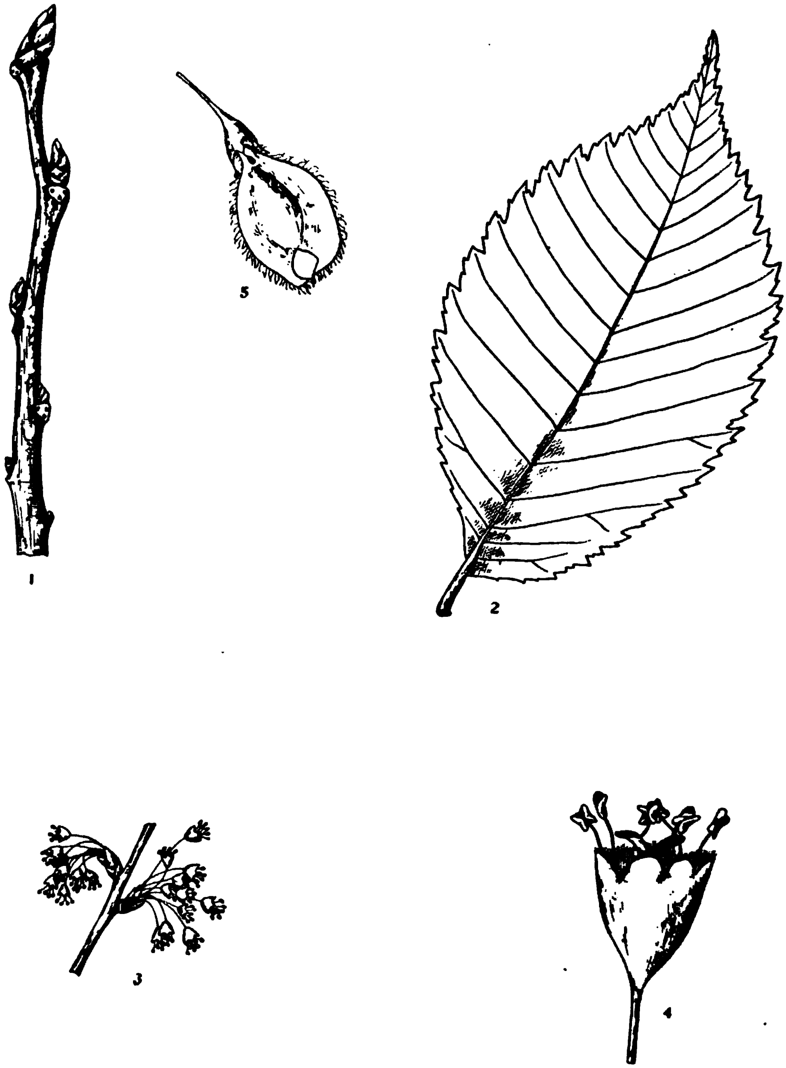
DISTRIBUTION.—Occasional throughout Vermont.

HABITAT.—Rich, rocky woods.

NOTES.—The slippery elm is not uncommon in Vermont. The scattering trees of this species, however, usually are passed unnoticed because it resembles the American elm so closely that it is not easy to distinguish the two by general appearance. The stringy mucilaginous bark of the slippery elm always is a sure means of recognition.

Other means of distinguishing it are found in its circular fruits, which appear in May; these have smooth margins, whereas those of both the other species are fringed with delicate hairs. The leaves are large, rough above and soft-downy beneath. But the surest and simplest test is the "slippery" bark. This has well-known medicinal properties which give it a recognized value in the drug trade. The slippery elm is usually found on rocky ridges and hillsides.

American Elm. White Elm



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Flower, enlarged.
5. Fruit, x 2.

URTICACEAE

American Elm. White Elm

Ulmus americana L.

HABIT.—A tree 75-100 feet high, with a trunk diameter of 2-6 feet; commonly dividing 20-30 feet above the ground into a few large branches which rise upward and outward to form a vase-shaped outline.

LEAVES.—Alternate, simple, 4-6 inches long, one-half as broad; obovate-oblong to oval; coarsely doubly serrate; thick and firm; dark green and rough above, pale and pubescent or glabrous beneath; petioles short and stout.

FLOWERS.—April, before the leaves; mostly perfect; small, brown to red; borne on slender pedicels in loose fascicles; calyx campanulate, 5-9-lobed; corolla 0; stamens 4-9, with bright red anthers; ovary 2-celled; styles 2, green.

FRUIT.—May; ovate, 1-seeded samaras, smooth both sides, hairy on the margin, ½ inch long, long-stemmed in crowded clusters.

WINTER-BUDS.—Terminal bud absent; lateral buds ovoid, acute, flattened, glabrous, brown, ⅛ inch long.

BARK.—Twigs at first light green and downy, becoming glabrous, red-brown, finally ash-gray; on old trunks thick, ash-gray, deeply fissured into broad, scaly ridges. Plate V.

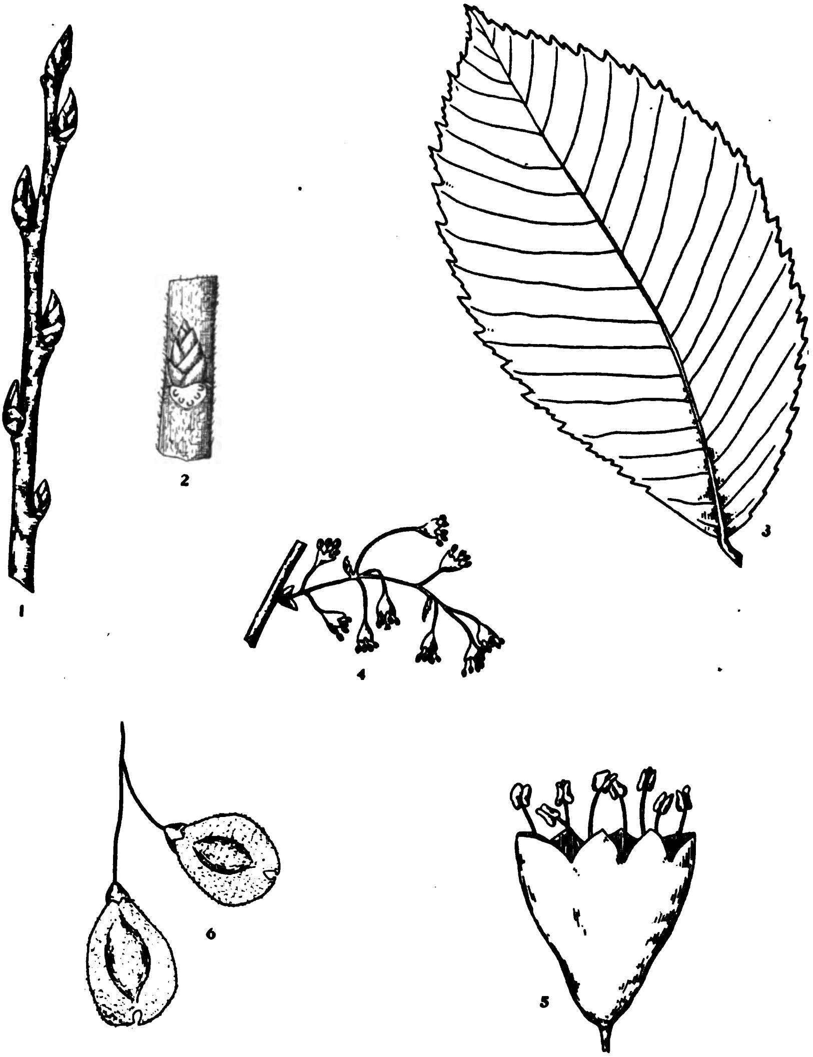
WOOD.—Heavy, hard, strong, tough, difficult to split, coarse-grained, light brown, with thick, lighter colored sapwood. Page 225.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Prefers deep, rich, moist loam; bottom-lands; stream-banks.

NOTES.—Of all the native trees none has done more than the white elm to beautify the streets of our cities and villages or to grace our country hillsides and meadows. The spreading vase-shaped head is its typical form, but perfect trees are found only where there has been a free development of the branches from the sapling age. Even when developing freely, however, the trees vary markedly in form. Some may be found which are very strict and upright others which are straggling and strongly weeping. The bark characters also vary much in different trees. Numerous clusters of slender, drooping flowers open before the leaves in early May, giving the tree a delicate feathery appearance. The seeds mature and fall before the leaves are grown fully. The wood is very tough and fibrous, making it useful for ox yokes, wagon bolsters, hubs of wheels and similar purposes where there is special cross-strain.

Cork Elm



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Flowering branchlet, x 1.
5. Flower, enlarged.
6. Fruit, x 1.

URTICACEAE

Cork Elm

Ulmus racemosa Thomas [Ulmus Thomasi Sarg.]

Habit.—A large tree reaching a height of 50-75 feet and a trunk diameter of 2-3 feet; strongly drooping lateral and lower branches form a narrow, oblong crown.

Leaves.—Alternate, simple, 3-6 inches long, one-half as broad; obovate to oblong-oval, more or less dished; coarsely doubly serrate; thick and firm; lustrous, dark green above, pale-pubescent beneath; petioles pubescent, ¼ inch long.

Flowers.—April-May, before the leaves; mostly perfect; greenish; borne on slender, drooping pedicels in loose racemes; calyx campanulate, 7-8-lobed; corolla 0; stamens 7-8, with purple anthers; ovary hairy, 2-styled.

Fruit.—May-June; ovate, 1-seeded samaras, pubescent all over, ½ inch long.

Winter-buds.—Terminal bud absent; lateral buds ovoid, acute, brown, pilose, ¼ inch long.

Bark.—Twigs at first light brown and pubescent, becoming lustrous, red-brown, finally gray-brown with corky, wing-like ridges; thick and grayish on the trunk, with wide fissures separating broad, flat, scaly ridges.

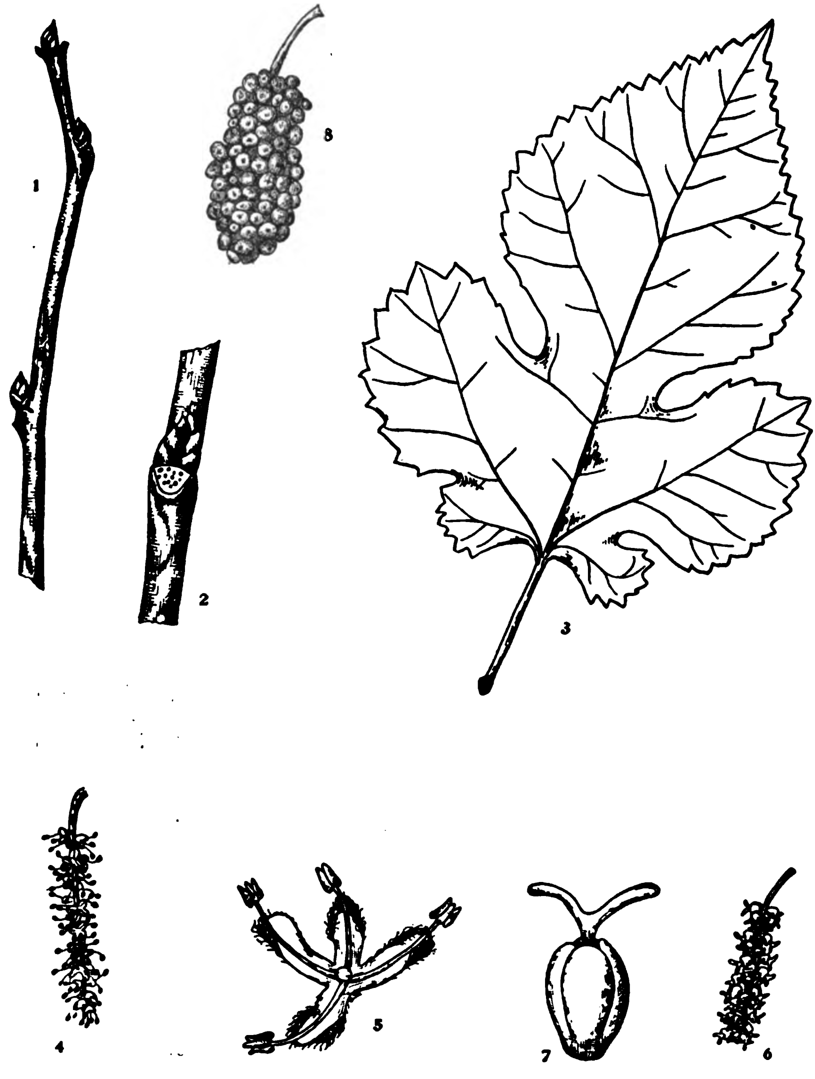
Wood.—Heavy, very strong and tough, close-grained, light red-brown, with thick, lighter colored sapwood.

Distribution.—Western Vermont, west of the Green mountains, becoming relatively more abundant in the Champlain valley; rare.

Habitat.—River-banks and limestone soils.

Notes.—The cork elm is a more valuable timber tree but it is found only in the limestone soils of western Vermont, and there but rarely. Its peculiarity is a growth of corky ridges which sometimes project for half an inch or more from all sides of the younger branches. The leaves resemble those of the white elm but are more conspicuously downy upon the under side along the midribs. The bud-scales are also downy and the young branchlets somewhat so, whereas those of the white elm are smooth. The flowers are borne in open branching clusters, or racemes, and this characteristic gives the Latin name to the species. The fruit matures when the leaves are half grown.

Red Mulberry



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Spike of staminate flowers, x 1.
5. Staminate flower, enlarged.
6. Spike of pistillate flowers, x 1.
7. Pistillate flower, enlarged.
8. Fruit, x 1.

URTICACEAE

Red Mulberry

Morus rubra L.

HABIT.—A small tree 15-20 feet high, with a short trunk 10-15 inches in diameter; forming a dense, rough-topped crown of stout, spreading branches and more or less zigzag, slender branchlets.

LEAVES.—Alternate, simple, 3-5 inches long, nearly as broad; outline variable, ovate to semiorbicular, often 3-5-lobed; coarsely serrate; thin; dark blue-green and smooth or rough above, pale and more or less downy beneath; petioles 1-2 inches long, smooth, exuding a milky juice when cut.

FLOWERS.—May, with the leaves; monoecious or dioecious; the staminate in dense spikes 1-2 inches long, on short, hairy peduncles; the pistillate in dense spikes about 1 inch long, on short, hairy peduncles; calyx 4-lobed, hairy; corolla 0; stamens 4, with green anthers; stigmas 2, spreading.

FRUIT.—July; 1 inch long; consisting of drupes about 1/32 inch long, each inclosed in a thickened, fleshy calyx; berry-like; bright red at first, finally blackish; sweet, juicy, edible.

WINTER-BUDS.—Terminal bud absent; lateral buds ovoid, abruptly pointed, 1/4 inch long, lustrous, light brown.

BARK.—Twigs greenish and more or less downy, becoming smooth and brownish; trunk dark brown tinged with red and more or less furrowed.

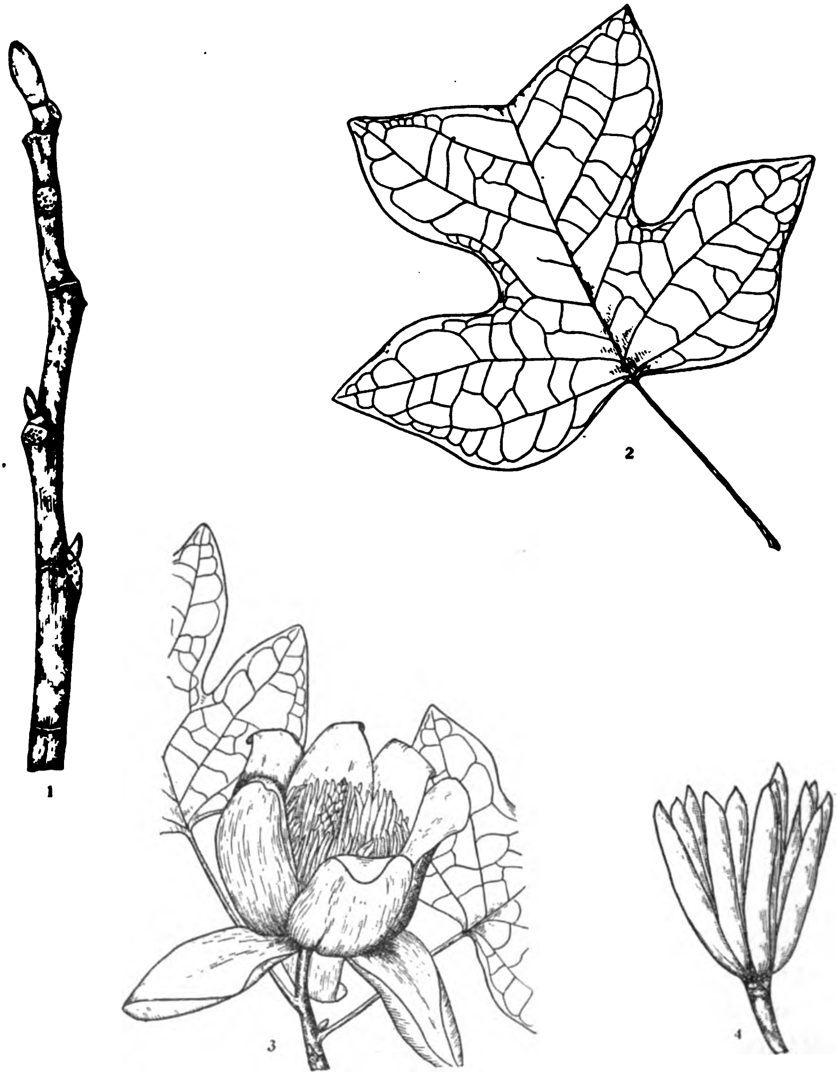
WOOD.—Light, soft, weak, rather tough, coarse-grained, very durable, pale orange, with thick, lighter colored sapwood.

DISTRIBUTION.—Rare; reported from Pownal and North Pownal in the Hoosic valley.

HABITAT.—Prefers rich soil in river-bottoms; rich woods.

NOTES.—The name mulberry is applied very commonly in Vermont to one of the wild raspberries, which has a conspicuous rose-like blossom followed by a reddish raspberry fruit. This shrub should be called the purple flowering raspberry since the true mulberries are trees. Two species of mulberry occur in Vermont; of these, the red is native, and the white is introduced, and occasionally is an escape. The fruit of both is edible, somewhat resembling that of the blackberry in size and appearance. The leaves are heart-shaped or ovate, often cut into curiously irregular lobes so that no two leaves on a branch will be exactly alike. This irregularity in leaf-form, together with the peculiar fruit, makes the recognition of the mulberry easy. Often it is difficult to distinguish the two species.

Tulip Tree. Yellow Poplar. Whitewood



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Fruit (opened and partly disseminated), x ½.

MAGNOLIACEAE

Tulip Tree. Yellow Poplar. Whitewood

Liriodendron tulipifera L.

HABIT.—A large tree 50-70 feet high, with a columnar trunk 2-3 feet in diameter; forming a rather open, conical crown of slender branches.

LEAVES.—Alternate, simple, 5-6 inches long and broad; 4-lobed; entire; lustrous, dark green above, pale or glaucous beneath, turning clear yellow in autumn; petioles slender, angled, 5-6 inches long.

FLOWERS.—June, after the leaves; perfect; terminal; solitary on stout peduncles; tulip-shaped, greenish yellow, 1½-2 inches long; sepals 3, greenish, early deciduous; petals 6, in 2 rows, greenish yellow with an orange spot at the base, early deciduous; stamens numerous, somewhat shorter than the petals; pistils numerous, clinging together about a central axis; ovary 1-celled.

FRUIT.—September-October; a narrow, light brown cone 2½-3 inches long, composed of numerous carpels; carpels long, flat, with a 1-2-seeded nutlet at the base, separating from the slender spindle at maturity.

WINTER-BUDS.—Terminal bud ½-1 inch long, obtuse, flattish, dark red, covered with a glaucous bloom.

BARK.—Twigs smooth, lustrous, reddish, becoming brownish, and at length gray; ashy gray, thin and scaly on young trunks, becoming thick, brownish, and deeply furrowed with age. Plate VI.

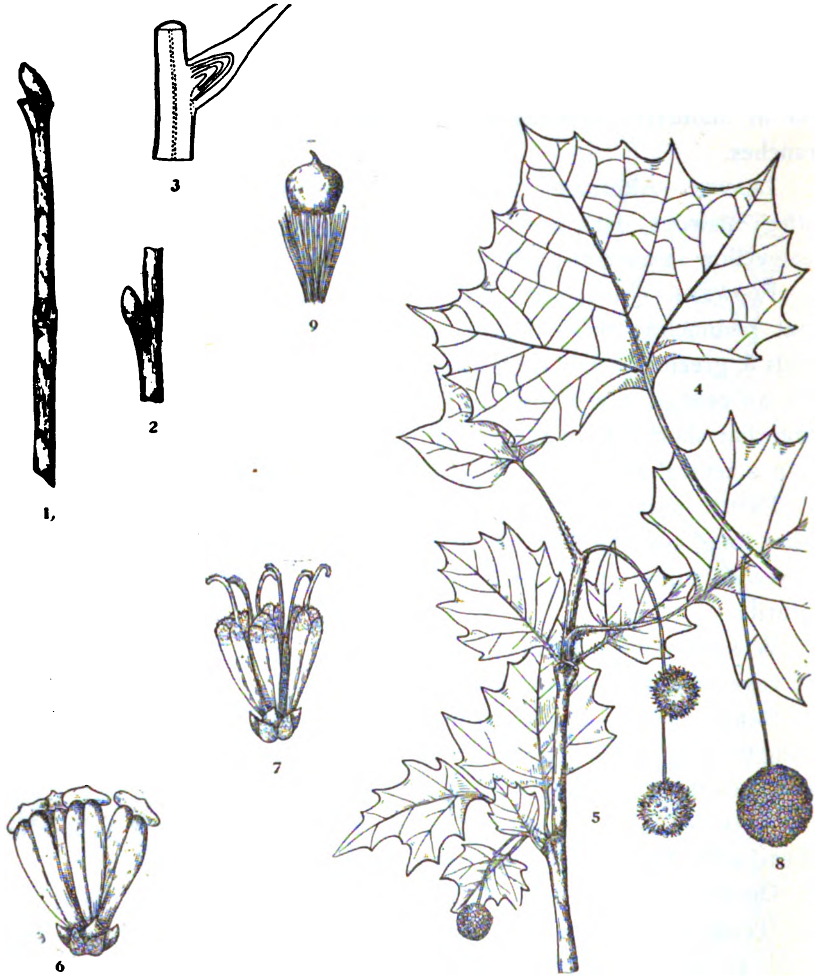
WOOD.—Light, soft, brittle, weak, easily worked, light yellow or brown, with thin, cream-white sapwood.

DISTRIBUTION.—Hoosic valley in southwestern Vermont; rare.

HABITAT.—Prefers deep, rich, rather moist soil, but adapts itself readily to any good, light soil.

NOTES.—The tulip tree is included in this list of native Vermont trees, although few native trees can be pointed out. The tree was reported authentically in the Appendix to Thompson's "Vermont" in 1853. It then occurred occasionally in Bennington county along the Hoosic valley. A single native specimen of this species is reported from North Pownal by Eggleston, showing that it is not yet extinct. It is to be hoped that tree lovers located in that portion of Vermont will learn and more fully report upon its present distribution, as this region marks its northern limit as a native tree. It thrives, however, as a shade tree planted in Rutland and Burlington. An attractive feature of this tree is its display of tulip-like flowers which open in June.

Sycamore. Buttonwood



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, side view, x 1.
3. Vertical section of twig, summer bud and leaf petiole, enlarged.
4. Leaf, x ⅜.
5. Flowering branchlet, x ½.
6. Staminate flower, enlarged.
7. Pistillate flower, enlarged.
8. Fruit, x ⅜.
9. Achene, enlarged.

PLATANACEAE

Sycamore. Buttonwood

Platanus occidentalis L.

HABIT.—A large tree 50-80 feet high, with a trunk diameter of 3-5 feet; commonly dividing near the ground into several large secondary trunks, forming a broad, open, irregular crown of massive, spreading branches.

LEAVES.—Alternate, simple, 5-10 inches long and broad; broadly ovate in outline; more or less 3-5-lobed by broad, shallow sinuses, the lobes sinuate-toothed; thin and firm; bright green above, paler beneath, glabrous both sides; petioles stout, puberulous, 1-2 inches long.

FLOWERS.—May, with the leaves; monoecious; borne in dense heads; the staminate dark red, on short, axillary peduncles; the pistillate greenish, on long, slender, terminal peduncles; sepals 3-6, minute; petals 3-6, minute; stamens 3-6, usually 4; styles long, incurved, red.

FRUIT.—October, persistent on the limbs through the winter; brown heads about 1 inch in diameter, on slender, glabrous stems 3-6 inches long.

WINTER-BUDS.—Terminal bud absent; lateral buds ¼-⅜ inch long, conical, blunt, lustrous, pale brown; forming in summer within the petiole of the leaf.

BARK.—Twigs pale green and tomentose, becoming smooth, dark green, finally grayish; thick, red-brown on the trunk and broken into oblong, plate-like scales, separating higher up into thin plates which peel off, exposing the greenish or yellowish inner bark. Plate VI.

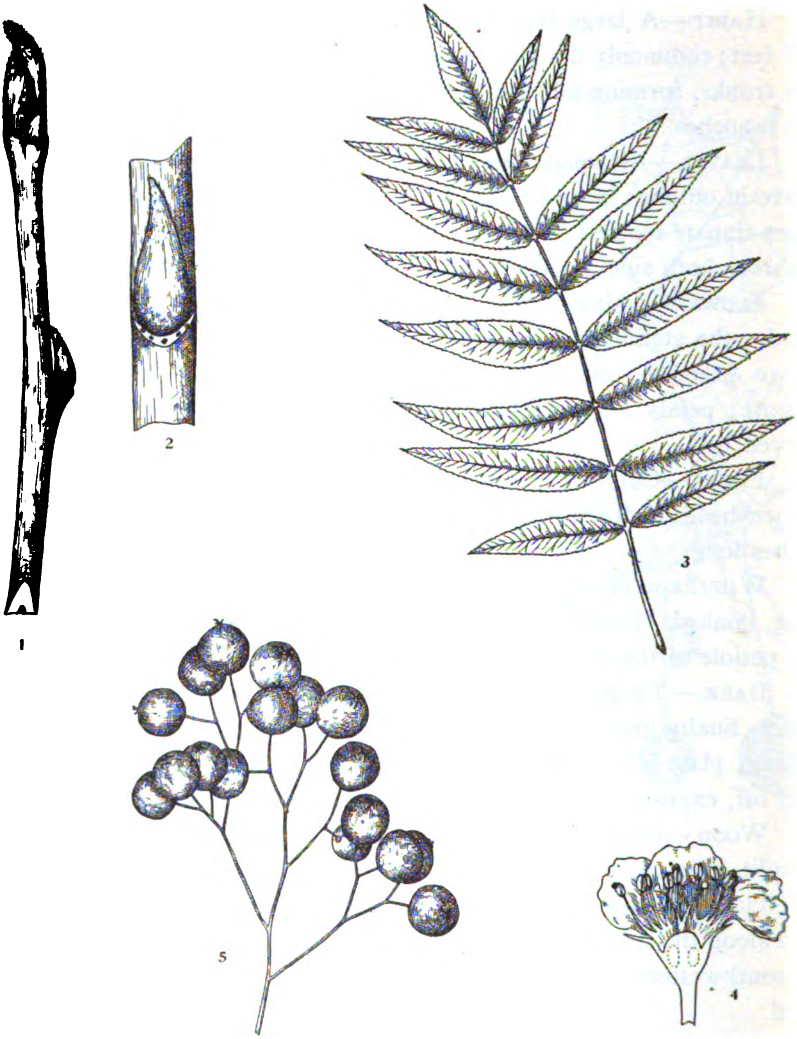
WOOD.—Heavy, tough, hard, rather weak, coarse-grained, difficult to split, light red-brown, with thick, darker colored sapwood.

DISTRIBUTION.—Occasional to frequent in the Champlain valley and along the tributary rivers, becoming abundant in the Hoosic valley in southwestern Vermont; Connecticut valley as far north as Hartford.

HABITAT.—Rich bottom-lands along the borders of rivers and lakes.

NOTES.—The bark unmistakably characterizes this species. On old trees this is brown and rough on the lower parts of the trunks, but above and on the branches it is smoother, with great, irregular, whitish or pale yellowish patches where the outer layers have scaled off, leaving the inner bark exposed. This gives the tree a whitewashed appearance when seen from a short distance.

American Mountain Ash



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ⅓.
4. Vertical section of flower, enlarged.
5. Portion of a fruiting cyme, x 1.

ROSACEAE

American Mountain Ash

Pyrus americana (Marsh.) DC. [Sorbus americana Marsh.]

HABIT.—A small tree 20-30 feet high, with a trunk diameter of 12-15 inches; branches slender, spreading, forming a narrow, rounded crown.

LEAVES.—Alternate, compound, 6-9 inches long. Leaflets 9-17, 2-3 inches long and ½-¾ inch broad; sessile or nearly so, except the terminal; lanceolate to oblong-lanceolate, taper-pointed; finely and sharply serrate above the entire base; membranaceous; glabrous, dark yellow-green above, paler beneath, turning clear yellow in autumn. Petioles slender, grooved, enlarged at the base.

FLOWERS.—May-June, after the leaves; perfect; ⅛ inch across; borne on short, stout pedicels in many-flowered, flat cymes 3-5 inches across; calyx urn-shaped, 5-lobed, puberulous; petals 5, white; stamens numerous; styles 2-3.

FRUIT.—October, but persistent on the tree throughout the winter; a berry-like pome, subglobose, ¼ inch in diameter, bright red, with thin, acid flesh; eaten by birds in the absence of other food.

WINTER-BUDS.—Terminal bud about ½ inch long, ovoid, acute, with curved apex; lateral buds smaller, appressed; scales rounded on the back, purplish red, more or less pilose above, gummy.

BARK.—Twigs at first red-brown and hairy, becoming glabrous, dark brown; thin, light gray-brown on the trunk, smooth, or slightly roughened on old trees; inner bark fragrant.

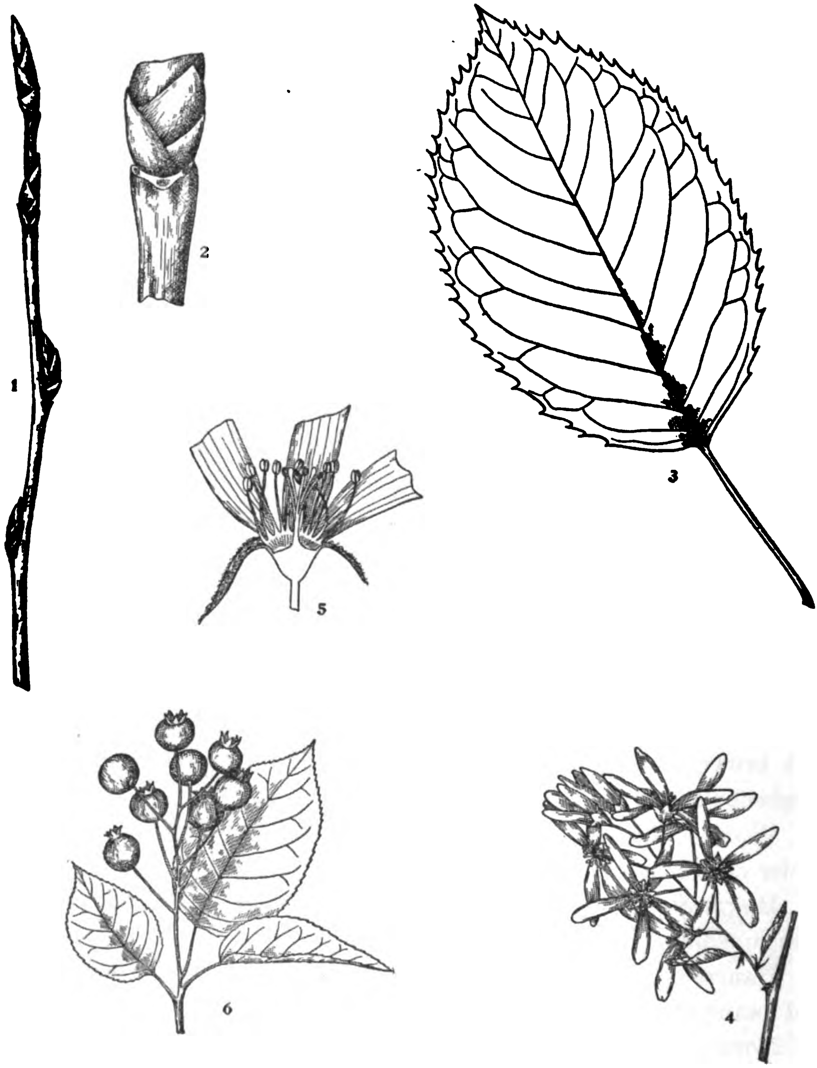
WOOD.—Light, soft, close-grained, weak, pale brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Frequent throughout Vermont, becoming common in the mountainous sections.

HABITAT.—Rich, moist soil on river-banks and on the borders of cold swamps; rocky hillsides and mountains.

NOTES.—This is one of the most beautiful trees of our northern forests. It is conspicuous among our trees for broad, flat-topped clusters of creamy white flowers followed by the persistent scarlet fruits. The common name is suggested by the general resemblance of the compound leaf to that of the ashes. In reality these trees are very closely related to the cultivated apples and pears, a fact which will become evident if one examines the structure of either the flower or the apple-like fruit. The European mountain ash, *Pyrus aucuparia (L.) Ehrh.* is planted commonly in Vermont for ornamental purposes and plants of this species are abundantly spontaneous in several localities.

Shadbush. Juneberry. Service Berry



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Flowering branchlet, x ½.
5. Vertical section of flower, enlarged.
6. Fruiting branchlet, x ½.

ROSACEAE

Shadbush. Juneberry. Service Berry

Amelanchier canadensis (L.) Medic.

HABIT.—A shrub or small tree 15-30 feet in height, with a tall trunk 6-12 inches in diameter; forming a narrow, rounded crown of many small limbs and slender branchlets.

LEAVES.—Alternate, simple, 3-4 inches long and about one-half as broad; ovate to obovate; finely and sharply serrate; glabrous, dark green above, paler beneath; petioles slender, about 1 inch long.

FLOWERS.—April-May, when the leaves are about one-third grown; perfect; large, white, borne in drooping racemes 3-5 inches long; calyx 5-cleft, campanulate, villous on the inner surface; petals 5, strap-shaped, white, about 1 inch in length; stamens numerous; styles 5, united below.

FRUIT.—June-August; globular, berry-like pome, ⅓-½ inch long; turning from bright red to dark purple with slight bloom; sweet and edible when ripe.

WINTER-BUDS.—Yellow-brown, narrow-ovoid to conical, sharp-pointed, ¼-½ inch long; bud-scales apiculate, slightly pubescent.

BARK.—Twigs smooth, light green, becoming red-brown; thin, pale red-brown on the trunk, smoothish or divided by shallow fissures into narrow, longitudinal, scaly ridges.

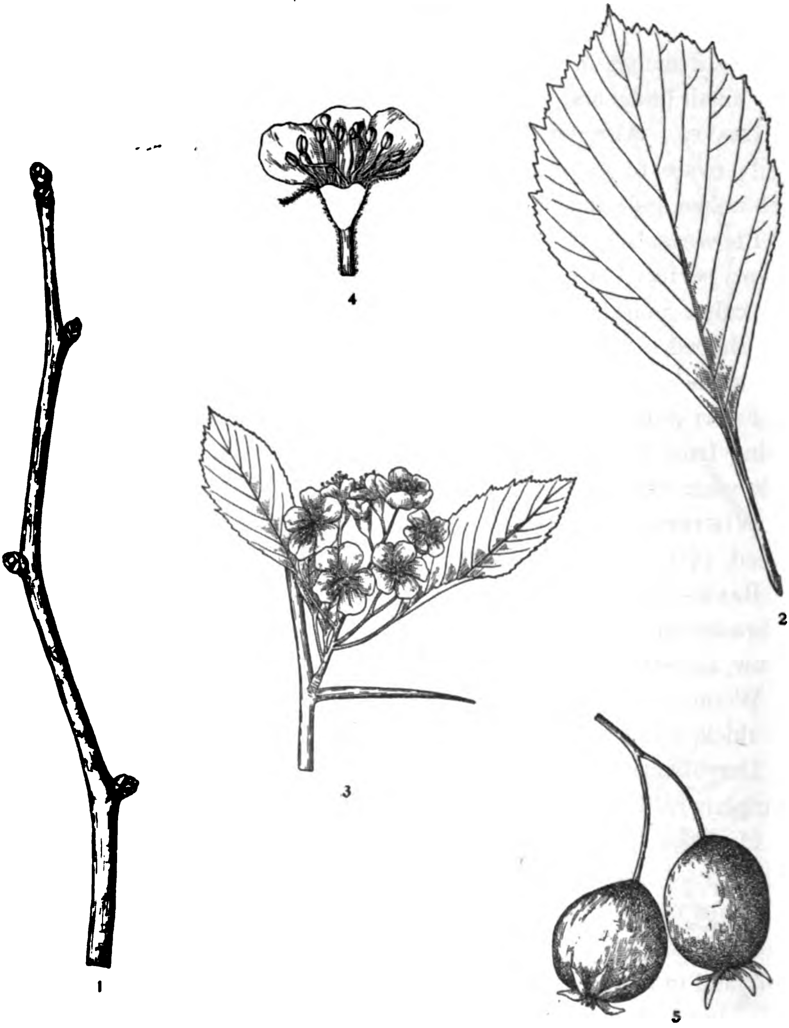
WOOD.—Heavy, very hard, strong, close-grained, dark red-brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Common throughout Vermont, especially in the Champlain valley.

HABITAT.—Dry, upland woods and hillsides; light soils.

NOTES.—Several other species occur in Vermont, most of which are shrubs below tree height. One is a small tree, however, becoming shrubby in the north. It differs but slightly from *Amelanchier canadensis* and until recently has not been distinguished from it. This new species has been named *Amelanchier laevis Wiegand.* It is said to be more northerly in its distribution than *Amelanchier canadensis.* The shadbush is easily recognized by its graceful white flowers which appear in the most lavish profusion in May before those of any other native fruit tree. The fruits which ripen in June are nearly one-half an inch long, purple, sweet and edible, but the birds make way with them so quickly that they are not often to be found. The shadbush is common in light soils and dry woodlands throughout Vermont, and especially so in parts of the Champlain valley. It ranges in size and habit from a bush to a small tree twenty to thirty feet in height.

Dotted Haw



(Mich. Trees).

1. **Winter twig, x 1.**
2. **Leaf, x 1.**
3. **Flowering branchlet, x ½.**
4. **Vertical Section of flower, enlarged.**
5. **Fruit, x 1.**

ROSACEAE

Hawthorns or Thorn-apples

Crataegus L.

Owing to the complexity of the various forms in this group, the present state of uncertainty as to the value of certain characters, and the questionable validity of many of the assigned names, it is thought to be beyond the scope of this bulletin to give more than a general description of the group as a whole, recommending the more ambitious student to the various manuals and botanical journals and papers for more detailed information.

The *Crataegi* are generally low, wide-spreading trees or shrubs, with strong, tortuous branches and more or less zigzag branchlets usually armed with stiff, sharp thorns. The bark varies from dark red to gray and is shallowly fissured or scaly. The leaves are alternate, simple, generally serrate, often lobed, with short or long petioles. The flowers appear in May or June, with or after the leaves, in simple or compound corymbs, whitish or pinkish, perfect. The fruit is a red to yellow, sometimes blue or black pome, subglobose to pear-shaped, with usually dry and mealy flesh and 1-5 seeds. The winter-buds are small, nearly globose, lustrous brown. *Crataegus* produces wood which is heavy, hard, tough, close-grained, red-brown, with thick, pale sapwood. The hawthorns are trees of the pasture-lands, the roadside, the open woods and the stream-banks, and are more common in the southern part of Vermont and in the lower altitudes, although some few species extend northward into Canada and some are found at considerable altitudes. Some of the species are desirable as ornaments in parks and gardens on account of their beautiful and abundant flowers and showy fruits.

THE PLUMS AND CHERRIES

The plums and cherries, particularly when in blossom, are among the most attractive trees in New England. They are all of small or medium size with conspicuous pink or white flowers. They are distinguished by their stone fruit and by their astringent bark and leaves. Seven species are found in Vermont. Only four of these are described in this bulletin. One of these, the choke cherry, seldom attains to the size or habit of a tree, but it is deemed best to include it here since it occurs so commonly along with the tree species that the omission might lead to some confusion.

SUMMER KEY TO THE SPECIES OF PRUNUS

a. Leaves oblong-ovate to obovate, abruptly acuminate at the apex; marginal teeth not incurved.

b. Margin of leaves sharp-serrate with spreading teeth; leaves not rugose, the veins not prominent; fruit ¼-½ inch long, bright red, racemose, July-August; bark of trunk brown, smooth or only slightly fissured; usually a large shrub, **P. virginiana,** p. 153.

bb. Margin of leaves crenate-serrate; leaves more or less rugose, the veins prominent; fruit about 1 inch long, orange-red, clustered, August-September; bark of trunk gray-brown, early splitting off in large, thick plates; a small tree...........**P. nigra,** p. 157.

aa. Leaves oval to oblong-lanceolate, taper-pointed at the apex; marginal teeth incurved.

b. Fruit light red, clustered, July-August; twigs usually less than 1/16 inch thick; pith of twigs brown... **P. pennsylvanica,** p. 155.

bb. Fruit black, racemose, August-September; twigs usually more than 1/16 inch thick; pith of twigs white...**P. serotina,** p. 151.

WINTER KEY TO THE SPECIES OF PRUNUS

a. Terminal bud present; bark of young trunks rather smooth.

b. Buds clustered at the tips of all shoots; twigs usually less than 1/16 inch thick; pith of twigs brown..**P. pennsylvanica,** p. 155.

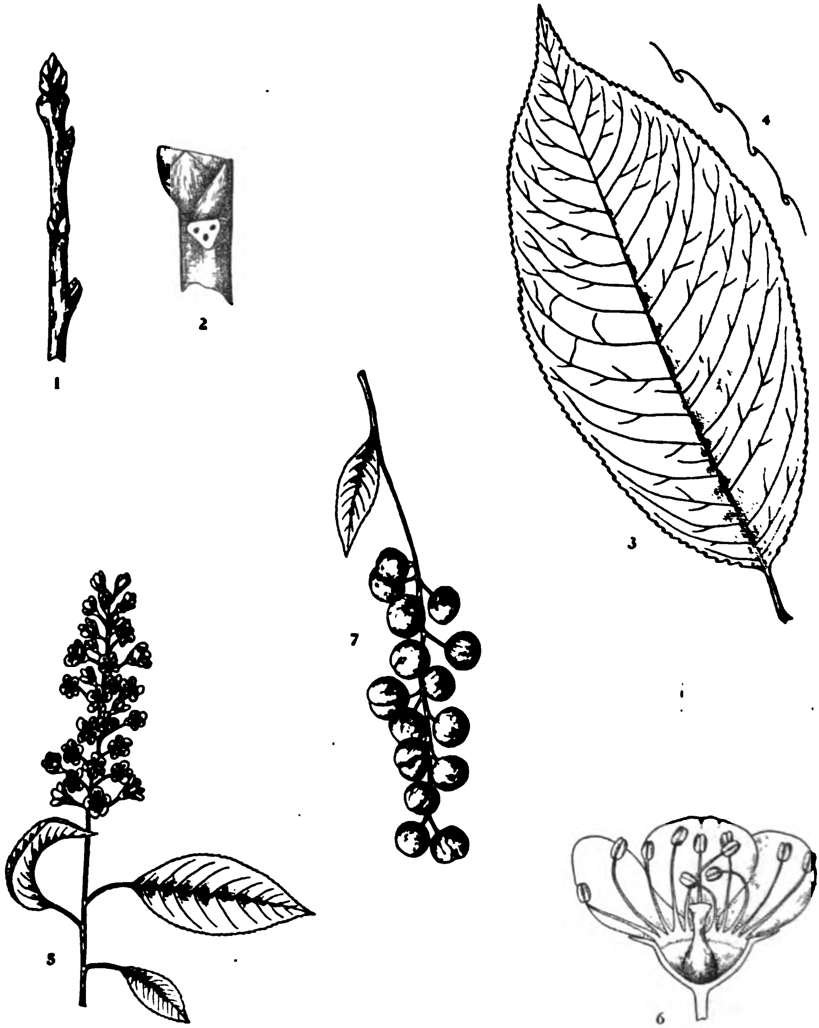
bb. Buds not clustered, or clustered only on short, spur-like branchlets; twigs usually more than 1/16 inch thick; pith of twigs white.

c. Buds usually ¼ inch or less in length; bud-scales uniform in color, apiculate at the apex; bark on old trunks blackish, rough-scaly; small to large tree...............**P. serotina,** p. 151.

cc. Buds usually ¼-½ inch long; bud-scales grayish on the margins, rounded at the apex; bark on old trunks brown, smooth or only slightly fissured; usually a large shrub, **P. virginiana,** p. 153.

aa. Terminal bud absent; bark of young trunks early splitting off in large, thick plates ....**P. nigra,** p. 157.

Black Cherry



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ¾.
4. Margin of leaf, enlarged.
5. Flowering branchlet, x ½.
6. Vertical section of flower, enlarged.
7. Fruiting branchlet, x ½.

ROSACEAE

Black Cherry

Prunus serotina Ehrh. [Padus serotina (Ehrh.) Agardh.]

HABIT.—A medium-sized tree 30-50 feet high and 8-24 inches in trunk diameter; branches few, large, tortuous, forming a rather spreading, oblong or rounded crown.

LEAVES.—Alternate, simple, 2-5 inches long, about one-half as broad; oval or oblong to oblong-lanceolate; finely serrate, with teeth incurved; subcoriaceous; dark green and very lustrous above, paler beneath, glabrous both sides; petioles short, slender, usually bearing 2 red glands near the blade.

FLOWERS.—May-June, when the leaves are half grown; perfect; ¼ inch across; borne on slender pedicels in many-flowered, loose racemes 4-5 inches long; calyx cup-shaped, 5-lobed; petals 5, white; stamens 15-20; stigma thick, club-shaped.

FRUIT.—August-September; a globular drupe, ⅓-½ inch in diameter, nearly black, with dark purple, juicy flesh; slightly bitter, edible.

WINTER-BUDS.—Terminal bud about ¼ inch long, ovoid, blunt to acute; scales keeled on the back, apiculate, light brown.

BARK.—Twigs and branches red to red-brown; young trunks dark red-brown, smooth; blackish on old trunks and rough, broken into thick, irregular plates; bitter, aromatic. Plate VI.

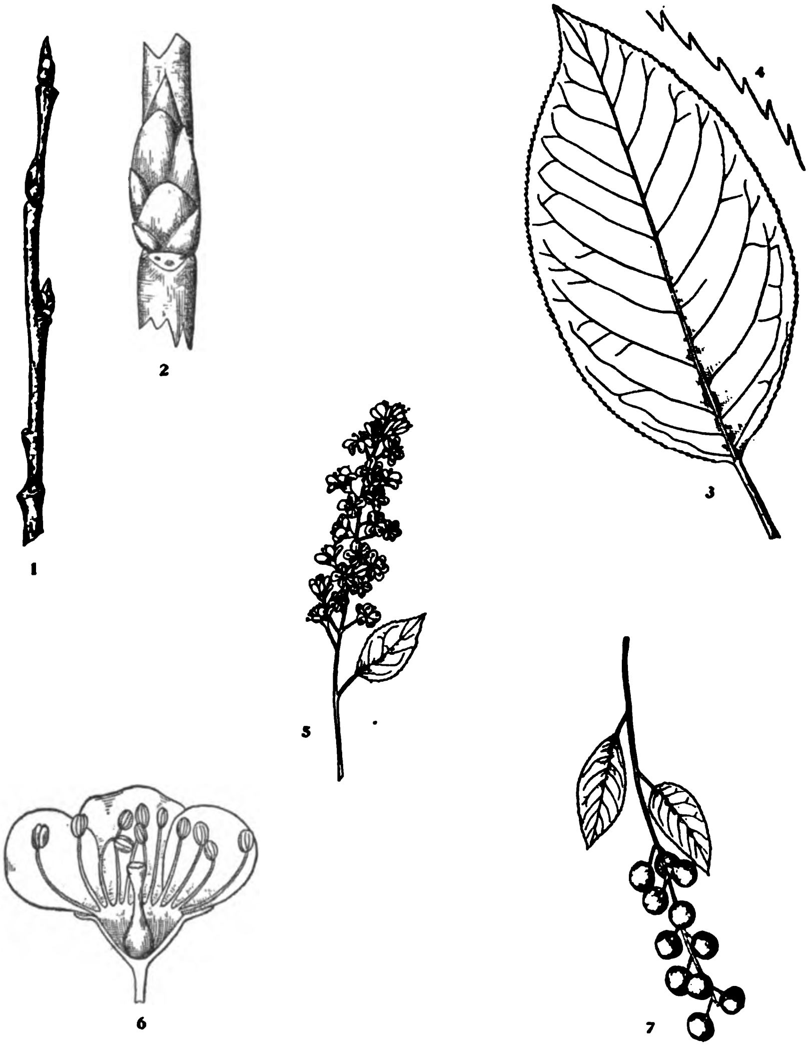
WOOD.—Light, rather hard, strong, close- and straight-grained, light brown or red, with thin, yellow sapwood.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Woodlands; in all sorts of soils and exposures.

NOTES.—This is the only native Vermont cherry which reaches a sufficient size to make it a valuable timber tree. It has been exported in considerable quantities from the southern part of Vermont, but now large trees are seldom found. The wood is of very superior quality for cabinet making, and commands the highest price of any native American timber. It has a beautiful grain and takes a very fine polish. The flowers resemble other cherry blossoms and are borne in racemes. The fruit at first is dark red, then becomes almost black, with a thick skin and dark juicy flesh, which generally is rather bitter but sometimes sweet and pleasant.

Choke Cherry



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Margin of leaf, enlarged.
5. Flowering branchlet, x ½.
6. Vertical section of flower, enlarged.
7. Fruit, x ½.

ROSACEAE

Choke Cherry

Prunus virginiana L. [Padus virginiana (L.) Roemer]

HABIT.—Usually a large shrub, but sometimes a small tree 15-25 feet high, with a crooked, often leaning trunk 5-6 inches in diameter; forming a spreading, somewhat rounded crown.

LEAVES.—Alternate, simple, 2-4 inches long, one-half as broad; obovate to oblong-obovate or oval, abruptly acuminate at the apex; finely and sharply serrate; dull dark green above, paler beneath, glabrous both sides; petioles short, slender, glandular at the apex.

FLOWERS.—May-June, when the leaves are half grown; perfect; about ½ inch across; borne on short, slender pedicels in many-flowered racemes 3-6 inches long; calyx cup-shaped, 5-lobed; petals 5, white; stamens 15-20; stigma broad, on a short style.

FRUIT.—July-August; a globular drupe, ¼-½ inch in diameter, usually bright red, often yellow to almost black, with dark red flesh; astringent, but edible.

WINTER-BUDS.—Terminal bud ¼-½ inch long, conical, acute; scales rounded at the apex, light brown, smooth.

BARK.—Twigs at first light brown or greenish, becoming red-brown, finally dark brown; thin, dark brown on the trunk, slightly fissured.

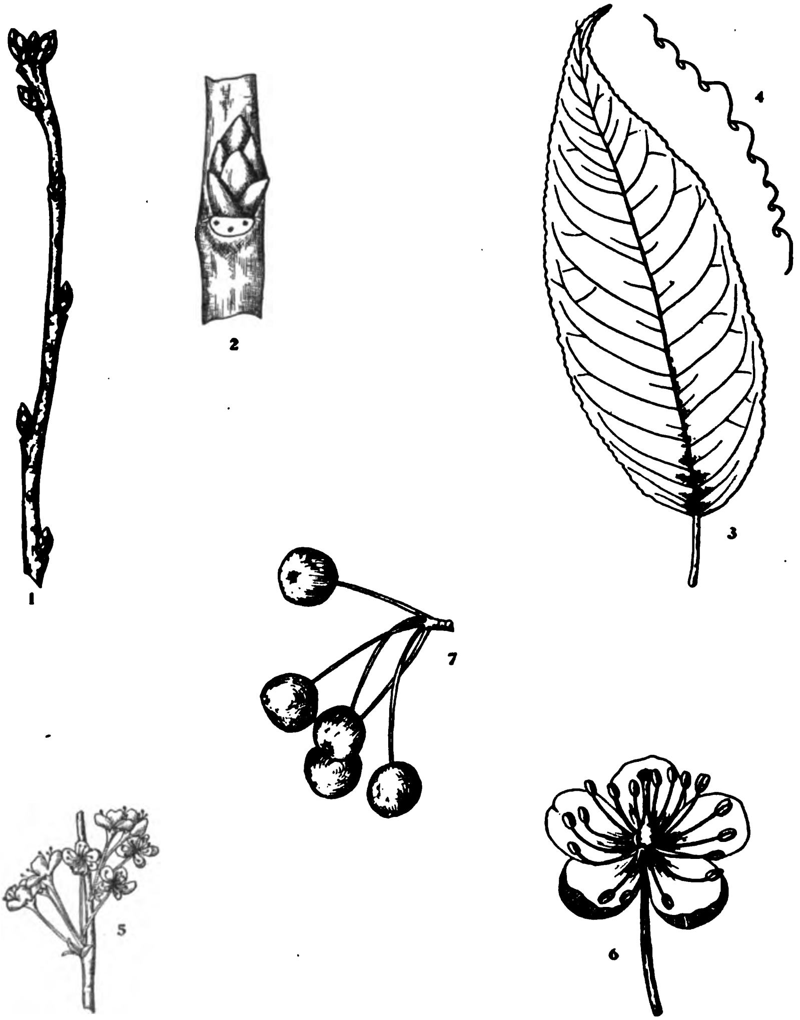
WOOD.—Heavy, hard, close-grained, weak, light brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Common throughout Vermont, even on the higher mountains.

HABITAT.—Fence-rows, woods and banks.

NOTES.—The choke cherry is the most widely distributed tree of North America, extending from the Arctic circle to Mexico, from the Rocky mountains to the Atlantic ocean. *Prunus virginiana leucocarpa,* a variety with short, dense racemes of flowers and sweet, yellowish fruit, has been reported from Lunenburg and Franklin. The choke cherry usually is a shrub in Vermont. It is included, however, in this list of trees because of its close relationship to the other cherries. In May, when the leaves are half grown, it is covered with creamy white flowers in long nodding clusters. The peculiarly astringent fruit, varying greatly in quality, however, ripens abundantly in August. It makes a good quality of jelly.

Wild Red Cherry. Bird Cherry. Pin Cherry



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Margin of leaf, enlarged.
5. Flowering branchlet, x ½.
6. Flower, enlarged.
7. Fruit, x 1.

ROSACEAE

Wild Red Cherry. Bird Cherry. Pin Cherry

Prunus pennsylvanica L. f.

HABIT.—A slender tree, seldom over 30 feet high, with a trunk diameter of 8-10 inches; crown rather open, narrow, rounded, with slender, regular branches.

LEAVES.—Alternate, simple, 3-5 inches long, ¾-1¼ inches broad; oblong-lanceolate; finely and sharply serrate; bright green and shining above, paler beneath; petioles slender, ½-1 inch long, glandular near the blade.

FLOWERS.—April-May, with the leaves; perfect; about ½ inch across, borne on slender pedicels in 4-5-flowered umbels, generally clustered, 2-3 together; calyx 5-cleft, campanulate; petals 5, white, ¼ inch long; stamens 15-20.

FRUIT.—July-August; a globular drupe, ¼ inch in diameter, light red, with thick skin and sour flesh.

WINTER-BUDS.—Terminal bud ⅛ inch long, broadly ovoid, rather blunt, brownish, smooth.

BARK.—Twigs at first lustrous, red, marked by orange colored lenticels, becoming brownish; red-brown and thin on the trunk, peeling off horizontally into broad, papery plates; bitter, aromatic.

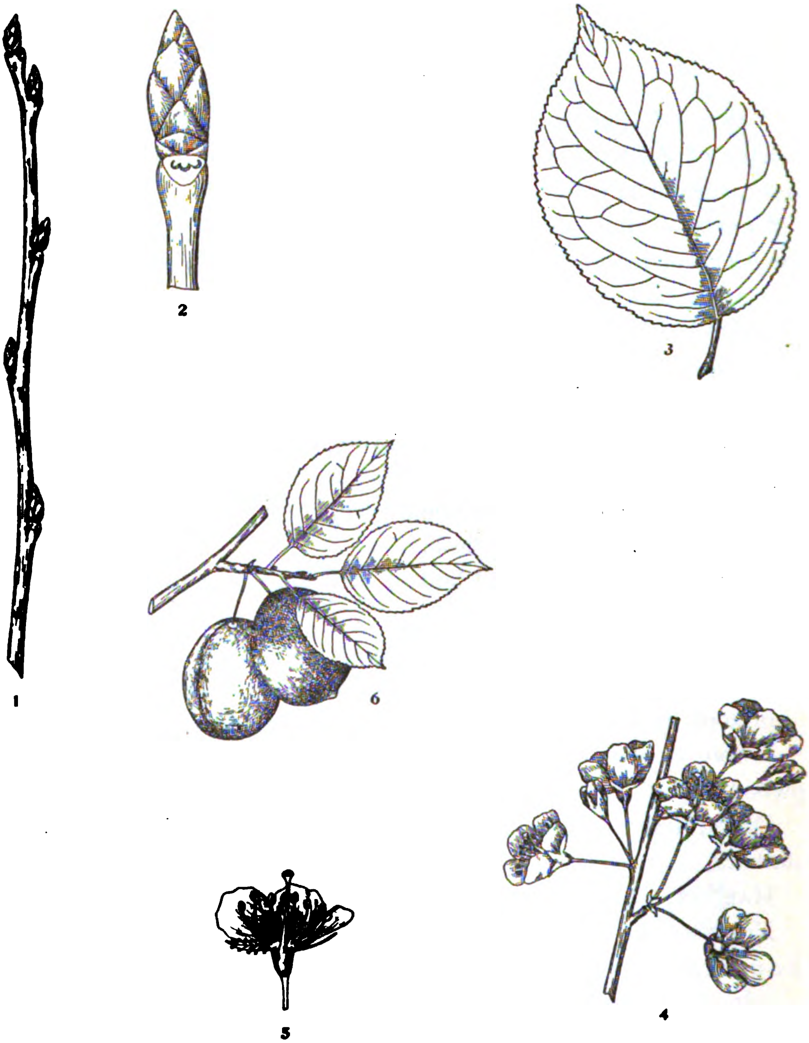
WOOD.—Light, soft, close-grained, light brown, with thin, yellow sapwood.

DISTRIBUTION.—Common throughout Vermont, even on the higher mountains.

HABITAT.—Roadsides; burned-over lands; clearings; hillsides.

NOTES.—The wild red cherry, a small, slender tree, is distributed quite generally from the rocky woods of Newfoundland to North Carolina. It is common in all parts of Vermont where often it is only a roadside shrub. The flowers appear in May on long pedicels in beautiful white clusters. The fruit, which ripens in midsummer, is small and globular, becoming bright red when mature. This tree is distinguished from the other cherries by its slender and more graceful form, by its lighter colored, close-growing bark, often covered with transverse scars (lenticels), by its small flowers in spreading clusters and by its very small globular fruit similarly clustered.

Wild Plum. Canada Plum



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ½.
4. Flowering branchlet, x ½.
5. Vertical section of flower, enlarged.
6. Fruiting branchlet, x ½.

ROSACEAE

Wild Plum. Canada Plum

Prunus nigra Ait. [Prunus americana, v. nigra Waugh]

HABIT.—A small tree 20-25 feet high and 5-8 inches in trunk diameter; usually divides 5-6 feet from the ground into a number of stout, upright branches, forming a narrow, rigid crown.

LEAVES.—Alternate, simple, 3-5 inches long and one-half as broad; oblong-ovate to obovate, abruptly acuminate at the apex; doubly crenate-serrate; thick and firm; glabrous, light green above, paler beneath; petioles short, stout, bearing 2 large red glands near the blade.

FLOWERS.—April-May, before the leaves; perfect; slightly fragrant; about 1 inch across; borne on slender, glabrous, red pedicels in 2-3-flowered umbels; calyx 5-lobed, dark red; petals 5, white; stamens 15-20, with purple anthers; ovary 1-celled; style 1; stigma 1.

FRUIT.—August-September; a fleshy drupe, about 1 inch long, oblong-ovoid, with a tough, thick, orange-red skin nearly free from bloom, and yellow flesh adherent to the flat stone. Eaten raw or cooked.

WINTER-BUDS.—Terminal bud absent; lateral buds ⅛-¼ inch long, ovate, acute, chestnut-brown.

BARK.—Twigs green, marked by numerous pale excrescences, later dark brown; thin, gray-brown and smooth on young trunks, but soon splitting off in large, thick plates, exposing the darker inner bark.

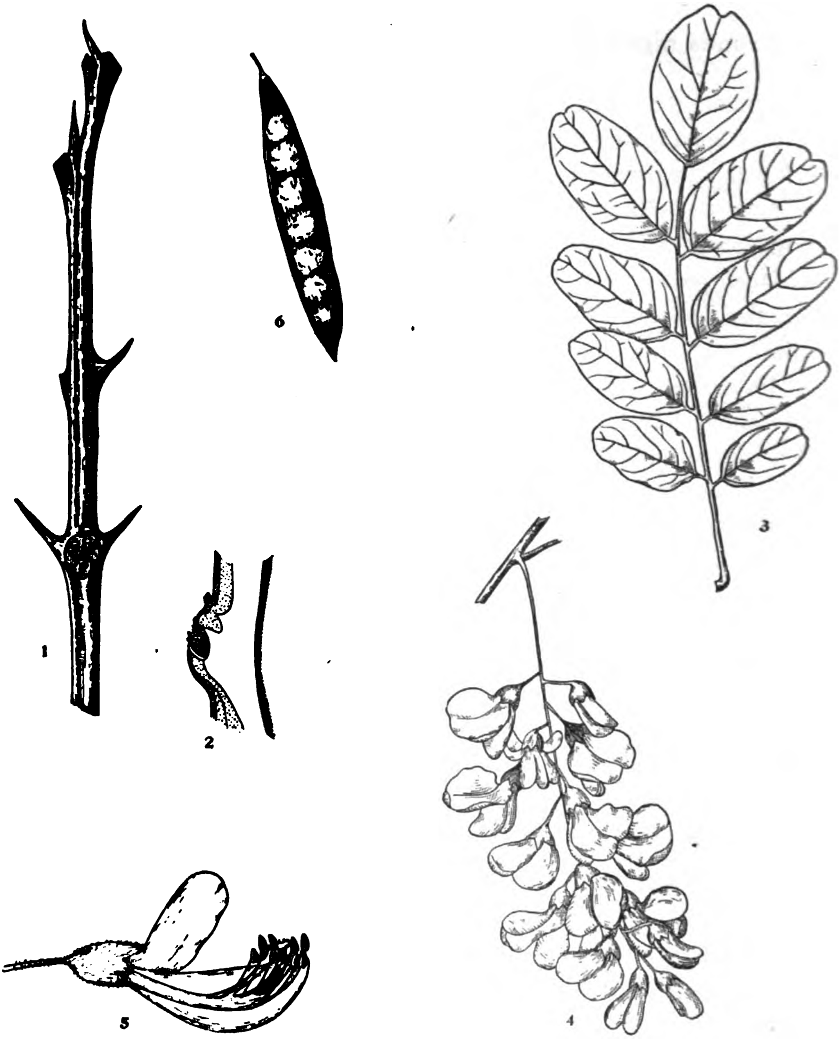
WOOD.—Heavy, hard, strong, close-grained, light red-brown, with thin, lighter colored sapwood.

DISTRIBUTION.—Frequent, especially in the northern portion of the state; never native in eastern Vermont.

HABITAT.—Woods; fence-rows.

NOTES.—The Canada plum, found frequently in Vermont, is a small tree or shrub, with gray-brown bark and short, spiny branchlets. It may be recognized by its broad, coarse leaves, sometimes four inches long and two or three inches wide. The flowers are abundant, large and strong, of a fine pinkish color, and appear about the first week in May. The fruit, often an inch in diameter, ripens in August. It is sometimes rather bitter, but occasional trees bear good eatable fruit.

Common Locust. False Acacia



(Mich. Trees).

1. Winter twig, x 1.
2. Vertical section through lateral bud, enlarged.
3. Leaf, x ½.
4. Raceme of flowers, x ½.
5. Flower, with part of corolla removed, enlarged.
6. Fruit, x ½.

LEGUMINOSAE

Common Locust. False Acacia

Robinia pseudo-acacia L.

HABIT.—A tree 50-75 feet high, with a trunk diameter of 2-3 feet; usually smaller; forming a narrow, oblong crown of irregular, more or less contorted branches.

LEAVES.—Alternate, compound, 8-14 inches long. Leaflets 7-21, short-petiolate, 1-2 inches long, about one-half as broad; ovate to oblong-oval; entire; very thin; dull dark green above, paler beneath, glabrous both sides. Petioles slender, pubescent.

FLOWERS.—June, after the leaves; perfect; showy and abundant; very fragrant; borne on slender pedicels in loose, drooping racemes 4-5 inches long; about 1 inch long; calyx short, bell-shaped, 5-lobed, hairy; corolla papilionaceous, white, 5-petaled; stamens 10.

FRUIT.—Late autumn, but persistent on the tree through the winter; a smooth, dark brown, flat pod 3-4 inches long, containing 4-8 small, flattish, brown seeds.

WINTER-BUDS.—Terminal bud absent; lateral buds minute, 3-4 superposed, partially sunken within the leaf-scar, rusty-hairy.

BARK.—Twigs smooth, green, more or less rough-dotted at first, becoming red-brown and armed with prickles; dark red-brown and thick on old trunk, deeply furrowed into firm, sinuous ridges. Plate VI.

WOOD.—Heavy, very strong and hard, close-grained, very durable in contact with the soil, brown, with very thin, pale yellow sapwood.

NOTES.—The common locust is a native of Pennsylvania and the more southern states. It has been widely planted in Vermont and frequently has run wild along fence-rows and about yards. The profusion of the fragrant, white, pea-like blossoms, the delicacy of the foliage and the picturesque form of the tree combine to make it very attractive. This locust is a large, rapidly growing tree, but it is attacked by borers and probably cannot be successfully grown in Vermont.

THE MAPLES

The maple family is a large one including nearly seventy species. Ten of these occur in the United States, and seven are found in Vermont. In many respects they form the most characteristic feature of our forest flora, and were Vermonters to select a state tree, popular choice certainly would be unanimous for the sugar maple.

The maples are distinguished easily from all other trees by their peculiar winged or "key" fruit. The leaves of all except the ash-leaved maple also are so similar as to form a good family character.

Two of the seven native species are as frequently shrubby as they are tree-like both in size and habit of growth, but all are included in this bulletin. By appealing to the size of the tree and characters of the leaves it is possible to distinguish the species.

Introduced species.—The Norway maple is a European species frequently used as a street shade tree farther south, and occasionally planted in Vermont. It most closely resembles the sugar maple among our native species but is easily distinguished by its broader and lower crown, larger leaves and larger, more divergent key-fruits.

Numerous horticultural varieties of the silver maple have been introduced in recent years, especially from Japan. These include very deeply cut-leaved forms, and also one with drooping branches. Their relationship to the native species is usually recognizable however.

The horse-chestnuts and buckeyes are closely related to the maples, although some authorities place them in a separate family. Of these the common horse-chestnut (*Aesculus hippocastanum*) is very commonly cultivated. It forms a large, clean, symmetrical tree, with rich foliage and showy blossoms. The buckeyes of the south and west are occasionally planted.

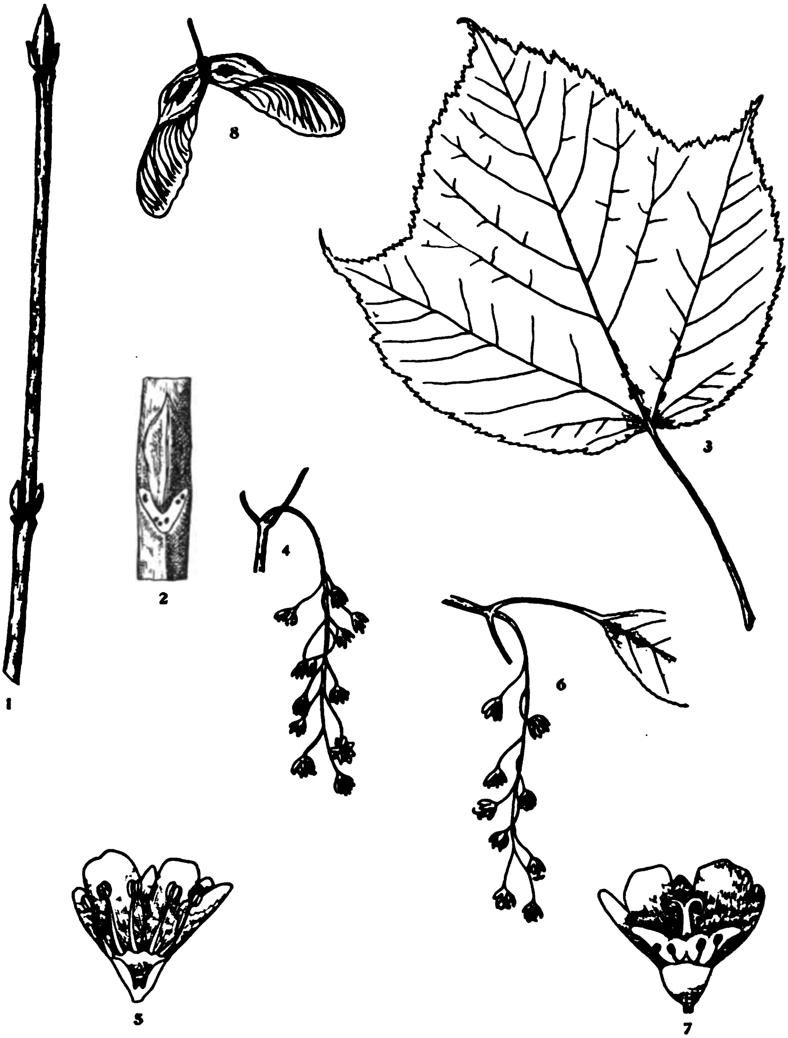
SUMMER KEY TO THE SPECIES OF ACER

a. Leaves simple; twigs usually without whitish bloom.
  b. Leaf-sinuses acute at the base.
    c. Leaf-lobes long and narrow, the sides of the terminal lobe diverging; leaves silvery white beneath; twigs rank-smelling when broken .... **A. saccharinum,** p. 173.
    cc. Leaf-lobes short and broad, the sides of the terminal lobe converging; leaves not conspicuously white beneath; twigs not rank-smelling when broken.
      d. Leaves distinctly white-downy beneath; twigs appressed-hairy, at least near the tip; fruit hanging in pendulous racemes, persistent on the tree until autumn; seed portion with pit-like depression on one side; usually a shrub or bushy tree .... **A. spicatum,** p. 167.
      dd. Leaves glabrous or nearly so beneath; twigs glabrous; fruit hanging in clusters, falling in early summer; seed portion without pit-like depression on one side; medium-sized tree .... **A. rubrum,** p. 175.
  bb. Leaf-sinuses rounded at the base.
    c. Lower sides of leaves and petioles distinctly downy, the lobes undulate or entire; leaves very thick, drooping at the sides, **A. saccharum nigrum,** p. 171.
    cc. Lower sides of leaves and petioles essentially glabrous, the lobes serrate; leaves not thick, not drooping at the sides.
      d. Leaves coarsely and sparsely toothed or notched; bark not longitudinally white-striped; fruit not in racemose clusters; large tree .... **A. saccharum,** p. 169.
      dd. Leaves finely and abundantly toothed; bark longitudinally white-striped; fruit in racemose clusters; a bushy tree or shrub .... **A. pennsylvanicum,** p. 165.
aa. Leaves compound; twigs usually with whitish bloom, **A. negundo,** p. 177.

WINTER KEY TO THE SPECIES OF ACER

a. Terminal buds usually under ¼ inch in length, not conspicuously stalked; bark not longitudinally white-striped.
  b. Buds white-woolly; twigs usually with a whitish bloom; opposite leaf-scars meeting; fruit often persistent on the tree until spring ....**A. negundo,** p. 177.
  bb. Buds not white-woolly; twigs without whitish bloom; opposite leaf-scars not meeting; fruit not persistent on the tree in winter.
    c. Buds reddish or greenish; twigs bright red.
      d. Twigs strictly glabrous; buds glabrous; spherical flower buds clustered on the sides of the shoot; pith pink; large trees.
        e. Twigs rank-smelling when broken; tip of outer bud-scales often apiculate; tips of branches curving upwards; bark separating into long, thin flakes loose at the ends, **A. saccharinum,** p. 173.
        ee. Twigs not rank-smelling when broken; tip of outer bud-scales rounded; tips of branches not conspicuously curving upwards; bark rough-ridged, but seldom forming loose flakes ....**A. rubrum,** p. 175.
      dd. Twigs appressed-hairy, at least near the tip; buds somewhat tomentose; spherical flower buds absent; pith brown; shrub or bushy tree.....................**A. spicatum,** p. 167.
    cc. Buds brownish; twigs brownish or grayish.
      d. Buds glabrous, or somewhat pubescent at the apex only; bark dark gray on the trunk.......**A. saccharum,** p. 169.
      dd. Buds hoary-pubescent; bark sometimes almost black on the trunk ....**A. saccharum nigrum,** p. 171.
aa. Terminal buds usually ¼-½ inch in length, conspicuously stalked; bark longitudinally white-striped...**A. pennsylvanicum,** p. 165.

Striped Maple. Moosewood



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ½.
4. Staminate flowering branchlet, x ½.
5. Vertical section of staminate flower, enlarged.
6. Pistillate flowering branchlet, x ½.
7. Vertical section of pistillate flower, enlarged.
8. Fruit, x ¾.

ACERACEAE

Striped Maple. Moosewood

Acer pennsylvanicum L.

HABIT.—A small tree at best, more often a large shrub, seldom attaining a height of more than 20 feet, with a short trunk 5-8 inches through. The striped, upright branches form a rather compact crown.

LEAVES.—Opposite, simple, 5-6 inches long and nearly as broad; 3-lobed above the middle with short, tapering lobes; palmately 3-nerved; sharply doubly serrate; rounded or heart-shaped at the base; glabrous, yellow-green above, paler beneath, turning pale yellow in autumn; petioles stout, grooved.

FLOWERS.—May-June, when the leaves are nearly full grown; usually monoecious; large bright yellow, bell-shaped, in slender, drooping racemes 4-6 inches long; calyx 5-parted; petals 5; stamens 7-8; ovary downy.

FRUIT.—Ripens in autumn; glabrous, paired samaras in long, drooping, racemose clusters, the wings ¾ inch long, widely divergent, and marked on one side of each nutlet by a small cavity.

WINTER-BUDS.—Bright red; terminal bud nearly ½ inch long, short-stalked, with bud-scales keeled; lateral buds smaller, appressed.

BARK.—Twigs light green, mottled with black, smooth; trunk and branches red-brown, marked longitudinally by broad, pale stripes.

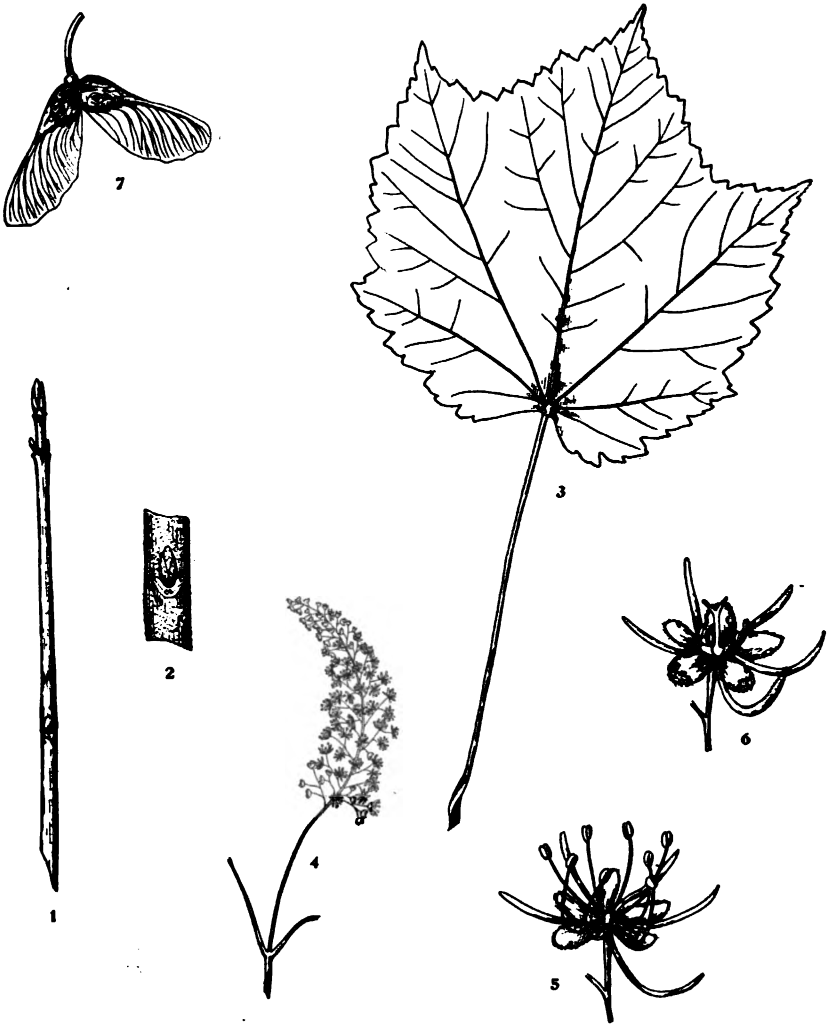
WOOD.—Light, soft, close-grained, pinkish brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Cool, rocky or sandy woods, in rich soil, usually in the shade of other trees.

NOTES.—The striped maple is a small tree or shrub which forms a familiar part of the undergrowth of our forests, and is a common roadside bush in all parts of Vermont. It is easily distinguished by its greenish bark striped longitudinally with darker lines. The leaves, the largest of the maples, are usually from five to seven inches long and four or five inches wide. Its drooping clusters of greenish flowers unfold by the middle of June when the leaves are nearly grown. The fruits are abundant and turn a beautiful scarlet towards autumn. This maple rarely exceeds a height of twenty feet. It also has a distinct value for ornamental planting, especially in groups or borders.

Mountain Maple



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ½.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruit, x 1.

ACERACEAE

Mountain Maple

Acer spicatum Lam.

HABIT.—A bushy tree sometimes 20 feet high, with a short trunk 4-6 inches in diameter; small, upright branches form a small, rounded crown. More often a straggling shrub.

LEAVES.—Opposite, simple, 4-5 inches long and two-thirds as broad; 3-lobed above the middle, the lobes coarsely crenate-serrate with pointed teeth, the sinuses usually wide-angled and acute at the base; thin; glabrous, dark green above, covered with a whitish down beneath, turning scarlet and orange in autumn; veining prominent; petioles long, slender, with enlarged base.

FLOWERS.—May-June, after the leaves are full grown; polygamo-monoecious; small, yellow-green, in erect, slightly compound, many-flowered, long-stemmed, terminal racemes; calyx downy, 5-lobed; petals 5; stamens 7-8; ovary tomentose.

FRUIT.—July-August; bright red, turning brown in late autumn; small, glabrous, paired samaras, in pendulous, racemose clusters.

WINTER-BUDS.—Small, flattish, acute, bright red, more or less tomentose; the terminal ⅛ inch long, containing the flowers.

BARK.—Twigs reddish, slightly hairy; very thin, red-brown, smooth or slightly furrowed on the trunk.

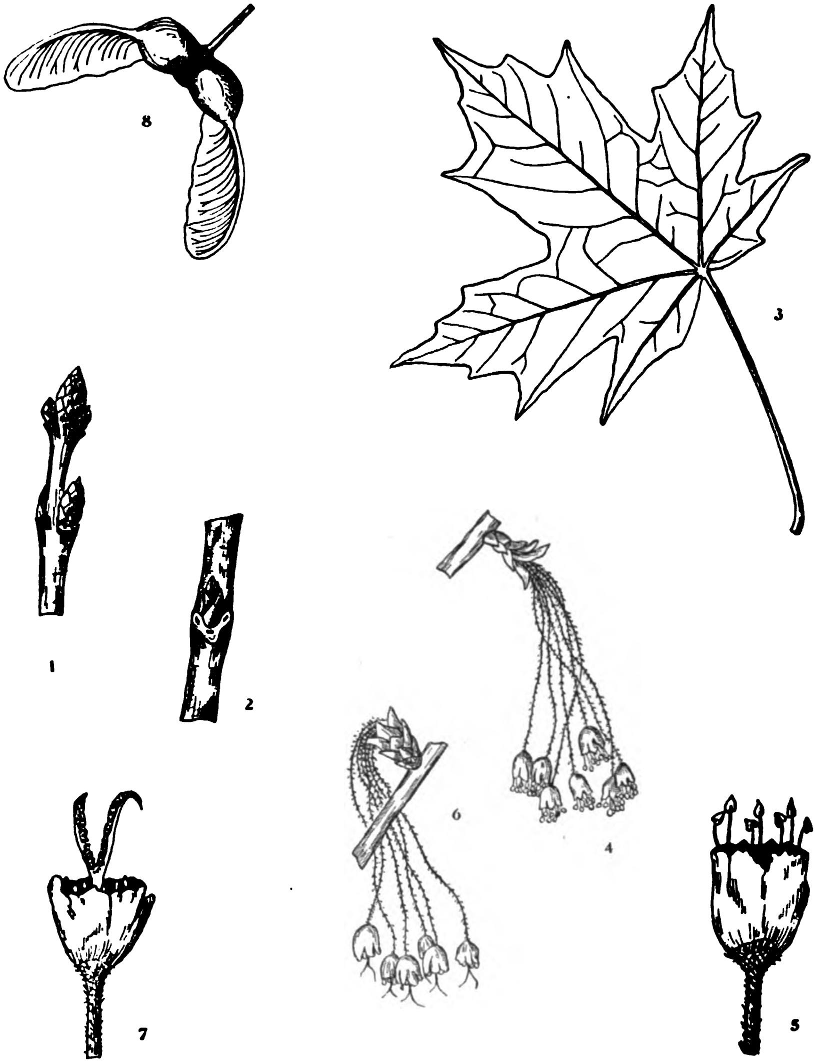
WOOD.—Light, soft, close-grained, light brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Of common occurrence throughout Vermont.

HABITAT.—Damp mountain forests; rocky woods; along streams and roadsides; cool ravines; always in the shade of other trees.

NOTES.—The mountain maple rarely becomes more than a shrub in Vermont. It occurs commonly in moist, rocky, mountain forests in all parts of the state. Like the striped maple it is partial to roadsides, and borders all our mountain driveways. The leaves are thin and downy on the under side. The yellowish green flowers are borne in erect pubescent clusters which appear in the latter part of June. It is the spike-like arrangement of these flowers which suggested the Latin name of the species. The fruits are very divergent, smaller than those of any other maple and become bright red in July and August. The heavy clusters then hang down and turn dark brown before being scattered by the winds. This maple is one of the most highly ornamental of the smaller trees, and worthy of more general cultivation.

Sugar Maple



(Mich. Trees).

1. Winter twig, x 2.
2. Portion of twig, enlarged.
3. Leaf, x ½.
4. Staminate flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flowering branchlet, x ½.
7. Pistillate flower, enlarged.
8. Fruit, x 1.

ACERACEAE

Sugar Maple. Rock Maple

Acer saccharum Marsh. [Acer saccharinum Wang.]

HABIT.—A stately tree 60-100 feet in height, with a trunk diameter of 3-4 feet; in the open forming stout, upright branches near the ground, in forests making remarkably clean trunks to a good height; the crown is a broad, round-topped dome.

LEAVES.—Opposite, simple, 3-5 inches long and broad; usually 5-lobed (sometimes 3-lobed), the lobes sparingly wavy-toothed, the sinuses broad and rounded at the base; thin and firm; opaque, dark green above, lighter and glabrous beneath, turning yellow and red in autumn; petioles long, slender.

FLOWERS.—April-May, with the leaves; polygamo-monoecious or dioecious; on thread-like, hairy pedicels in nearly sessile corymbs; greenish yellow; calyx campanulate, 5-lobed; corolla 0; stamens 7-8; ovary hairy.

FRUIT.—September-October, germinating the following spring; paired samaras, glabrous, with wings about 1 inch long, diverging slightly.

WINTER-BUDS.—Small, acute, red-brown, glabrous or somewhat pubescent toward the apex, the terminal ¼ inch long, the lateral smaller, appressed.

BARK.—Twigs smooth, pale brown, becoming gray and smooth on the branches; old trunks dark gray, deeply furrowed, often cleaving up at one edge in long, thick plates. Plate VII.

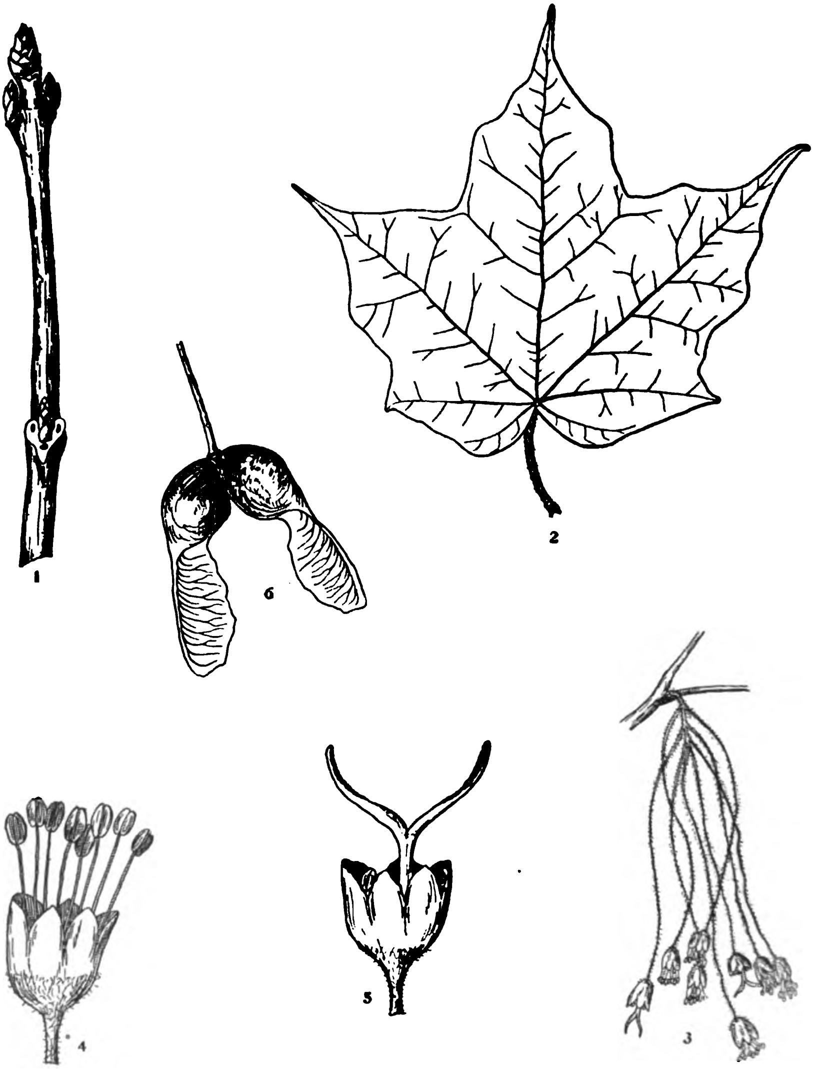
WOOD.—Heavy, hard, strong, close-grained, tough, durable, light brown, with thin, lighter colored sapwood. Page 223.

DISTRIBUTION.—Found throughout Vermont.

HABITAT.—Prefers moist, rich soil in valleys and uplands and moist, rocky slopes.

NOTES.—The sugar maple is everywhere in Vermont, but it thrives best on the cool and rocky uplands. It can be distinguished by its light gray bark which has large, white patches on the younger branches or by its broad, five-lobed leaves which have shallow, rounded, sinuses. In the sugar-bushes of Vermont, trees three and four centuries old not infrequently are found. Besides its value as a sugar tree, its timber is hard and durable. The "curled" and "bird's-eye" maple are unusual forms of this species, produced by a peculiar curling of the fibers.

Black Sugar Maple



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

ACERACEAE

Black Sugar Maple

Acer saccharum nigrum (Michx. f.) Britt. [Acer nigrum Michx.]

HABIT.—A stately tree, sometimes reaching a height of 80 feet, with a trunk diameter of 2-3 feet; branches stout, forming a broad, rounded, symmetrical crown.

LEAVES.—Opposite, simple, concave, 5-7 inches across, the breadth usually exceeding the length; usually 5-lobed at maturity, the two lower lobes being small, often reduced to a mere curve in the outline, the pointed lobes undulate or entire and narrowed from the broad, shallow sinuses; thick and firm; glabrous above, downy beneath; petioles stout, usually pendent, tomentose. The sides of the larger leaves often droop giving to the tree an air of depression.

FLOWERS.—May, with the leaves; monoecious; in nearly sessile, umbel-like corymbs; about ¼ inch long, yellow, on slender, hairy pedicels 2-3 inches long; calyx campanulate, pilose, 5-lobed; corolla 0; stamens 7-8; ovary hairy.

FRUIT.—Ripens in autumn; glabrous, paired samaras, clustered on drooping pedicels; wings set wide apart, but only slightly diverging.

WINTER-BUDS.—Small, ovoid, acute, with dark red-brown, acute scales, hoary-pubescent on the outer surface.

BARK.—Twigs smooth, pale gray; becoming thick, deeply furrowed and sometimes almost black on the trunk.

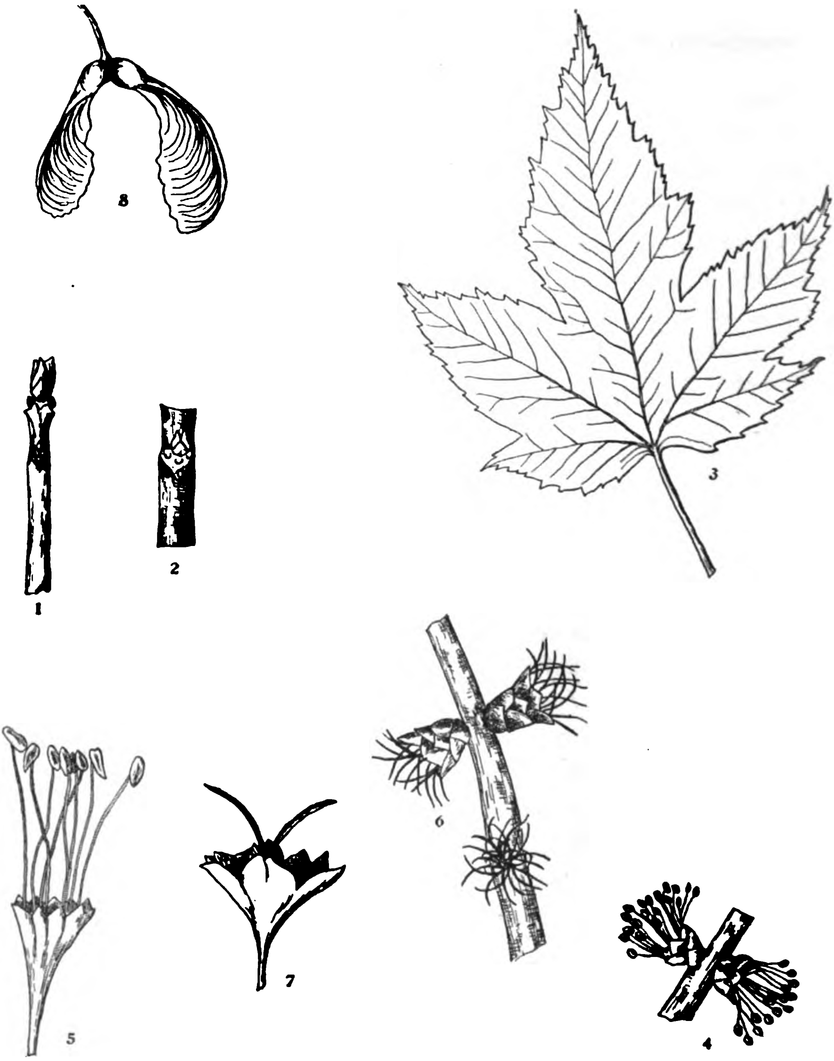
WOOD.—Hard, heavy, strong, close-grained, creamy white, with thin, lighter colored sapwood.

DISTRIBUTION.—Lake Champlain valley. Occasional.

HABITAT.—Low, moist, rich soil of river-bottoms.

NOTES.—This tree has long been a puzzle to botanists. In leaf characters it differs considerably from the sugar maple, but resembles it in fruit characters, general habit and in sugar production. As indicated in the key, the leaf is less deeply lobed, and is minutely hairy on the lower face; it may be hairy also along the leaf stalk. It is thicker and more leathery in texture and usually is heart-shape at the base, the rounded basal lobes sometimes overlapping. This black sugar maple should not be confused with specimens of the ordinary sugar maple having darker bark. Sugar-makers often term such trees "black maples." The bark of this black sugar maple generally is dark, but the leaf characters must be appealed to in its recognition.

White Maple. Silver Maple



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ½.
4. Staminate flowering branchlet, x 1.
5. Staminate flower, enlarged.
6. Pistillate flowering branchlet, x 1.
7. Pistillate flower, enlarged.
8. Fruit, x ½.

ACERACEAE

White Maple. Silver Maple

Acer saccharinum L. [Acer dasycarpum Ehrh.]

HABIT.—A beautiful tree, growing to a height of 60-80 feet, with a trunk diameter of 2-4 feet, usually separating near the ground into 3-4 upright stems which are destitute of branches for a considerable distance. Usually the long, slender branches bend downwards, but with their tips ascending in a graceful curve. Crown broad, especially in its upper portion.

LEAVES.—Opposite, simple, 3-6 inches long and nearly as broad; usually 5-lobed by narrow, acute sinuses which extend nearly to the midrib, the lobes often sublobed, sharply toothed; light green above, silvery white beneath, turning pale yellow in autumn; petioles long, slender, drooping.

FLOWERS.—April-May, before the leaves; polygamo-monoecious or dioecious; small, yellow-green, in crowded, sessile umbels; calyx 5-lobed (sometimes each lobe again divided); corolla 0; stamens 3-7; ovary hairy.

FRUIT.—May, germinating as soon as it reaches the ground; paired samaras, large, glabrous, curving inwards, one samara often aborted.

WINTER-BUDS.—Dark red, blunt; the terminal about ¼ inch long, with bud-scales often apiculate; flower-buds clustered on side spurs.

BARK.—Twigs smooth, red-gray, lustrous; young trunks gray, smooth; old trunks dark gray, more or less furrowed, separating into thin, loose scales. Plate VII.

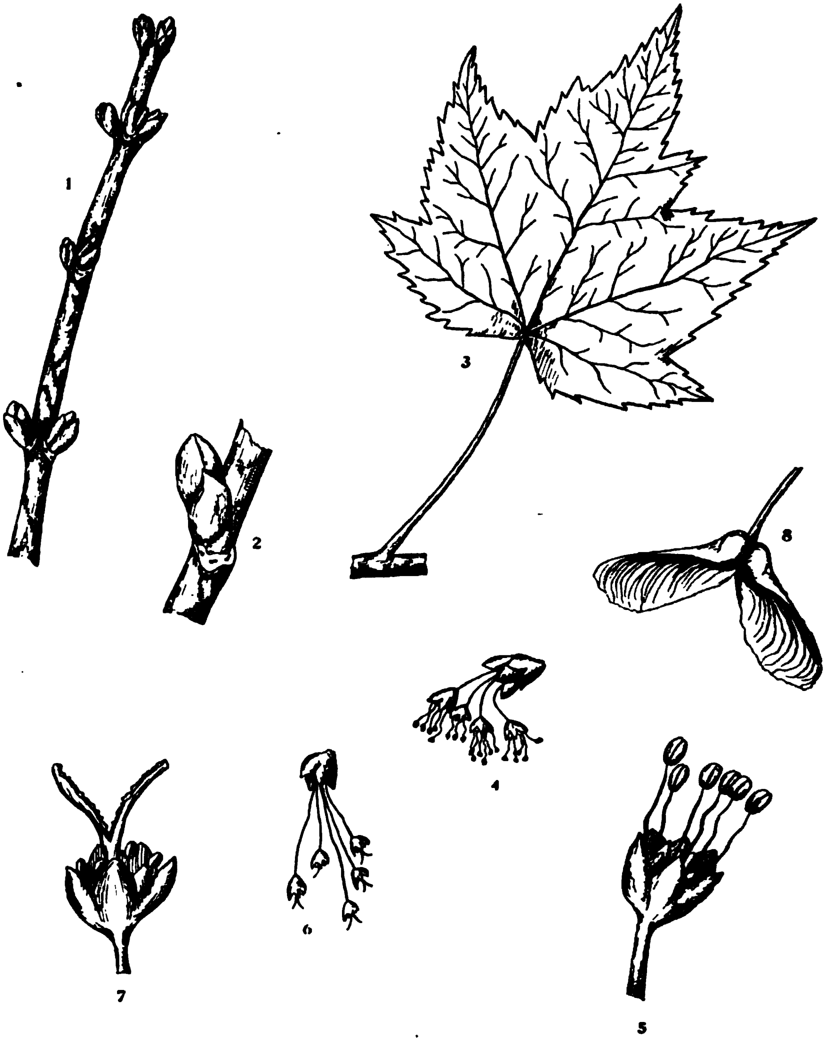
WOOD.—Hard, strong, close-grained, rather brittle, perishable, pale brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Frequent throughout Vermont, especially near the shores of Lake Champlain and tributary streams.

HABITAT.—Prefers low, rich bottom-lands, subject to occasional inundation, but not in swamps; banks of rivers and lakes at low altitudes.

NOTES.—The silver maple is a large, graceful tree, generally distributed along our water courses, especially near the shores of Lake Champlain and the streams emptying into it. It resembles the red maple but is distinguished from it by its longer, more deeply cut, lighter green leaves which are silvery white on the lower side. Although the silver maple flourishes best in moist soil, it will make vigorous growth and become a beautiful shade tree in dry locations.

Red Maple. Swamp Maple



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Fascicle of staminate flowers, x 1.
5. Staminate flower, enlarged.
6. Fascicle of pistillate flowers, x 1.
7. Pistillate flower, enlarged.
8. Fruit, x ¾.

ACERACEAE

Red Maple. Swamp Maple

Acer rubrum L.

HABIT.—A medium-sized tree 40-50 feet high, occasionally in swamps 60-75 feet; trunks 1-3 feet in diameter; upright branches, which form a low, rather narrow, rounded crown.

LEAVES.—Opposite, simple, 3-4 inches long and nearly as broad; 3-5-lobed by broad, acute sinuses, the lobes irregularly doubly serrate or toothed; glabrous, green above, whitish and generally glabrous beneath, turning bright scarlet in autumn; petioles long, slender.

FLOWERS.—April-May, before the leaves; polygamo-monoecious or dioecious; in few-flowered fascicles on shoots of the previous year, the pistillate red, the staminate orange; sepals 4-5; petals 4-5; stamens 5-8; ovary smooth.

FRUIT.—May-June, germinating immediately after reaching the ground; samaras small, on drooping pedicels 2-4 inches long; wings about 1 inch long, diverging at about a right angle.

WINTER-BUDS.—Dark red, blunt; terminal bud about ⅛ inch long, with bud-scales rounded at the apex; flower-buds clustered on side spurs.

BARK.—Twigs bright red, lustrous, becoming smooth and light gray on the branches; old trunks dark gray, ridged, separating into plate-like scales. Plate VII.

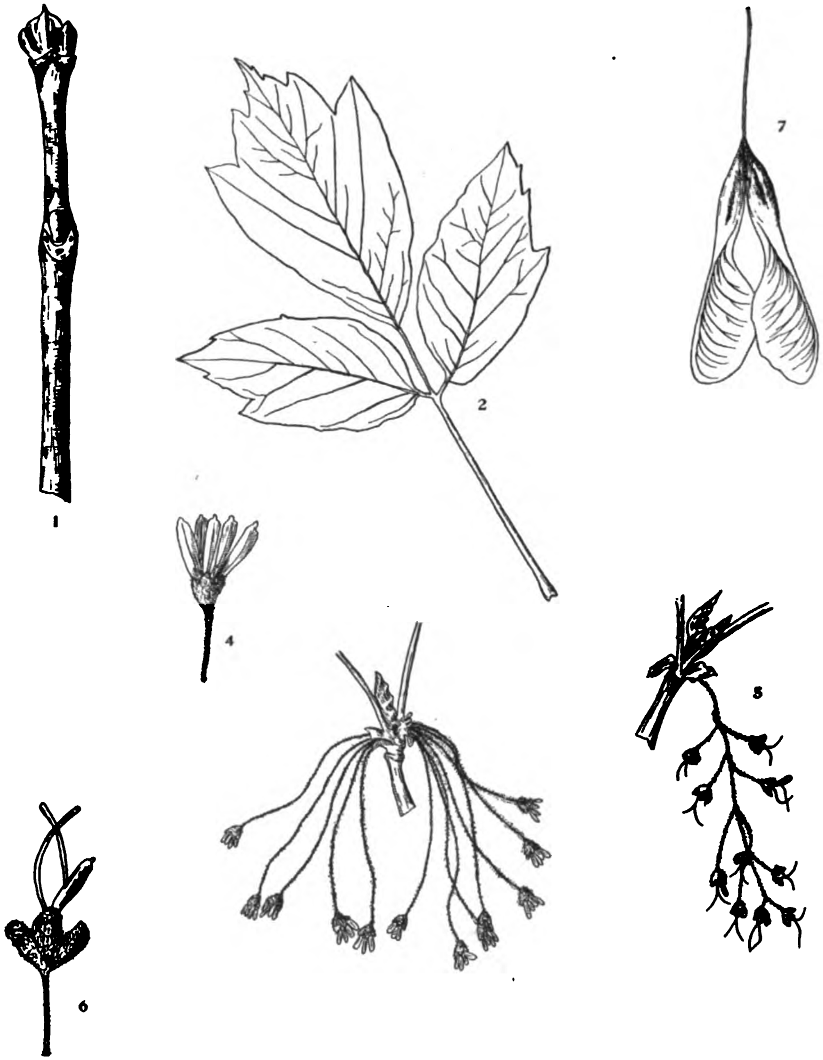
WOOD.—Heavy, close-grained, not strong, light brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Prefers swamp-lands or banks of streams; moist woods.

NOTES.—The scarlet flowers of this maple give us the brightest spring welcome from the trees. When the red maple is a blaze of color and the other trees are still bare and brown, it is conspicuous and unmistakable, and in autumn the rich coloring of its leaves makes it conspicuous again. The leaves of the silver maple turn yellow and those of the sugar maple yellow or red, but not the crimson or deep red of the red maple. It is distinguished from the sugar maple by its smoother, dark gray bark and by the deeper acute incisions of the leaves although they are subject to much variation. The fruit is about one inch long and like that of silver maple falls in early summer. This tree, common throughout the eastern United States, is very generally distributed in Vermont.

Box Elder



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x 1.

ACERACEAE

Box Elder

Acer negundo L. [Negundo aceroides Moench.]

Habit.—A sturdy little tree 30-40 feet high, with a trunk diameter of 1-2 feet. Trunk often divides near the ground into several stout, wide-spreading branches, forming a broad, unsymmetrical, open crown.

Leaves.—Opposite, pinnately compound. Leaflets 3-5 in number, 2-4 inches long, 1½-2½ inches broad; ovate or oval; nearly entire, irregularly and remotely coarse-toothed above the middle, or sometimes 3-lobed (often giving the leaflet a jagged outline); apex acute, base variable; glabrous or somewhat pubescent at maturity, with prominent veins. Petioles slender, 2-3 inches long, the enlarged base leaving prominent crescent-shaped scars partly surrounding the winter-buds.

Flowers.—April-May, before or with the leaves; dioecious; small, yellow-green; the staminate in clusters on long, thread-like, hairy pedicels; the pistillate in narrow, drooping racemes; calyx hairy, 5-lobed; corolla 0; stamens 4-6; ovary pubescent.

Fruit.—Early summer, but hanging until late autumn or early spring; narrow, flat, winged samaras, in pairs, clustered in drooping, racemose clusters.

Winter-buds.—Terminal bud ⅛-¼ inch long, acute, inclosed in two dull red scales, often hoary or minutely pubescent; lateral buds obtuse, appressed.

Bark.—Twigs greenish to purple, glaucous; trunk pale gray or light brown, deeply cleft into broad ridges.

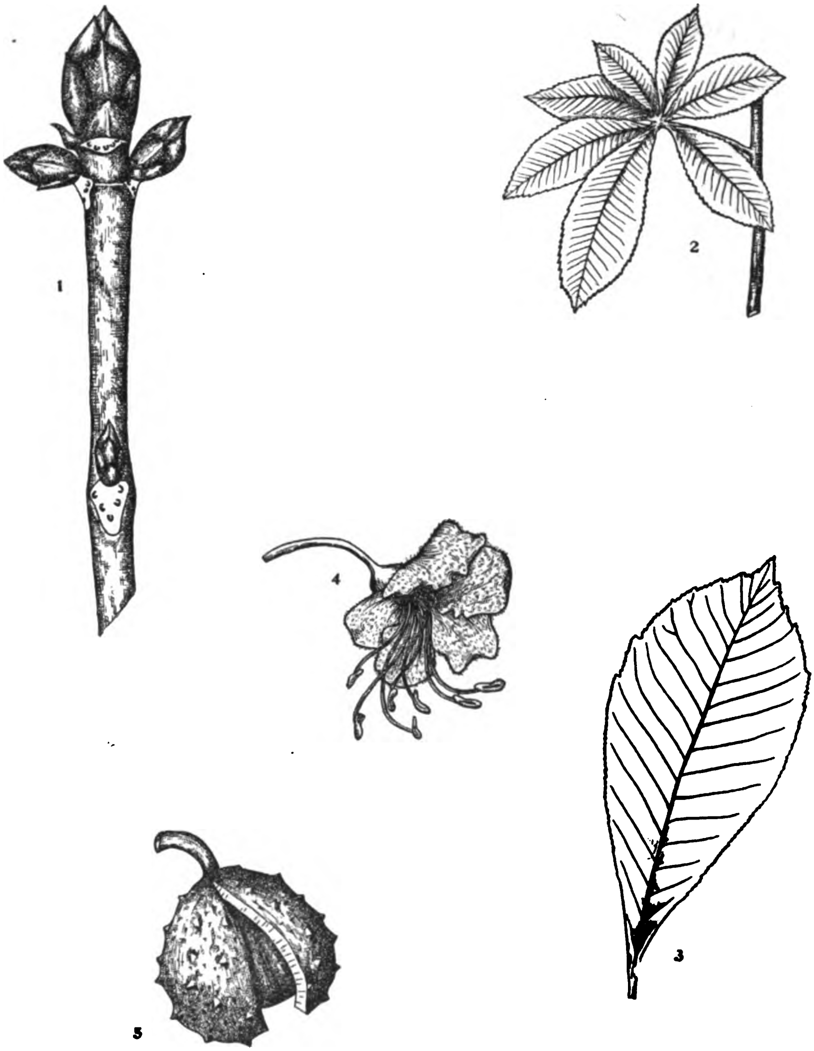
Wood.—Light, soft, close-grained, weak, creamy white, with thick, hardly distinguishable sapwood.

Distribution.—From the Winooski river southward, in some places locally abundant; occurs sparingly along streams in the Champlain valley.

Habitat.—Banks of streams and borders of swamps. Prefers deep, moist soil.

Notes.—The box elder accommodates itself to almost any situation. It is easily transplanted and grows rapidly. For these reasons it is sometimes planted for shade and ornament, but it is not a desirable tree for this purpose.

Common Horse-chestnut



(Mich. Trees).

1. **Winter twig, x ¾.**
2. **Leaf, x ⅙.**
3. **Leaflet, x ½.**
4. **Flower, x 1.**
5. **Fruit, x ½.**

SAPINDACEAE

Common Horse-chestnut

Aesculus hippocastanum L.

Habit.—A handsome tree, with a height of 40-60 feet and a trunk diameter of 1-2 feet, forming a broad, conical crown. The regularly occurring branches ascend from the trunk at first, gradually bend downwards as they lengthen, and end in a thick, upturning spray.

Leaves.—Opposite, digitately compound. Leaflets usually 7, rarely 5, 5-7 inches long, 1½-2½ inches broad; obovate, wedge-shaped at the base; irregularly and bluntly serrate; thick; rough, dark green above, paler beneath, turning a rusty yellow in autumn. Petioles long, grooved, swollen at the base.

Flowers.—May-June, after the leaves; polygamo-monoecious; large, whitish, in showy, upright, terminal thyrses 8-12 inches long; pedicels jointed, 4-6-flowered; calyx campanulate, 5-lobed; petals 5, white, spotted with yellow and red, clawed; stamens 7, thread-like, longer than the petals.

Fruit.—October; a leathery, globular capsule about 2 inches in diameter, roughened with short spines; containing 1-3 large, smooth, lustrous, brown nuts, marked by large, pale scars.

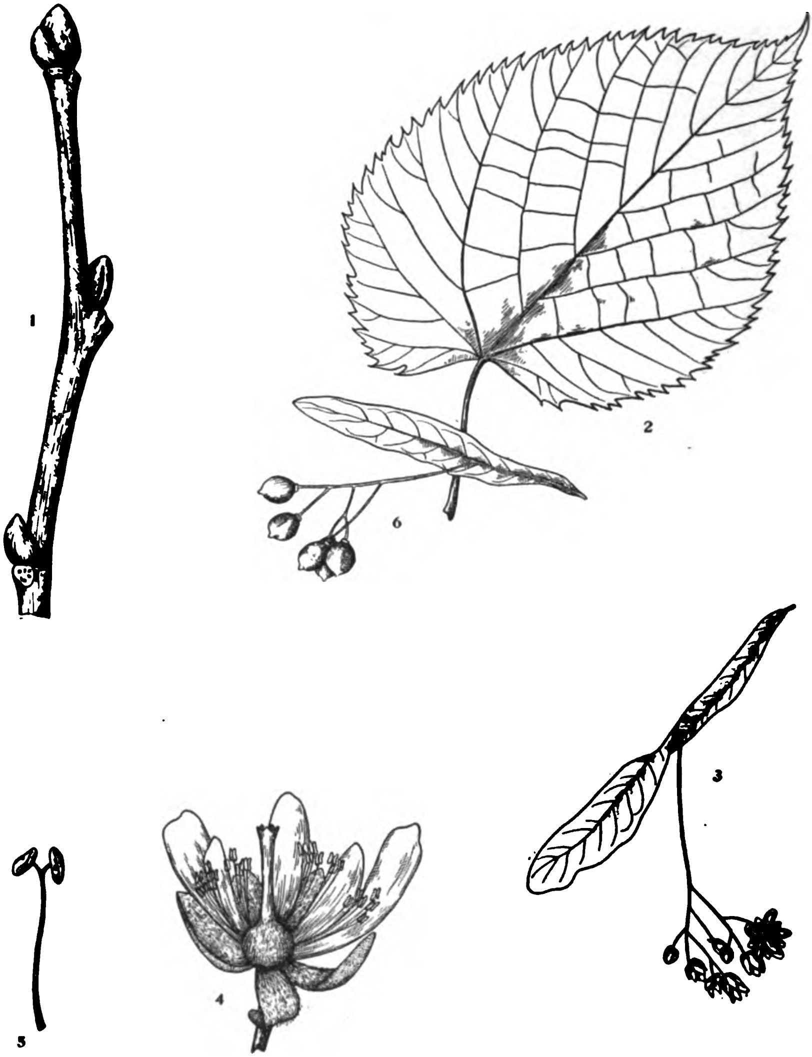
Winter-buds.—Terminal buds 1-1½ inches long, acute, brownish, covered with glistening, resinous gum; inner scales yellowish, becoming 1½-2 inches long in spring, remaining until the leaves are nearly half grown.

Bark.—Twigs smooth, red-brown; trunk dark brown and broken into thin plates by shallow fissures; rich in tannin, bitter.

Wood.—Light, soft, close-grained, weak, whitish, with thin, light brown sapwood.

Notes.—The horse-chestnut is a native of Greece, but it is extensively cultivated throughout Europe and America, where it is favorite shade tree. A double-flowered variety, *Aesculus hippocastanum, v. flòre plèno,* which bears no fruit is a common garden form.

Basswood



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Cyme of flowers, with its bract, x ½.
4. Flower, with two petals, petaloid scales and stamens removed, enlarged.
5. Stamen, enlarged.
6. Fruit, x ½.

TILIACEAE

Basswood

Tilia americana L.

HABIT.—A tree usually 60-70 feet high, with a tall, straight trunk 2-4 feet in diameter; numerous slender branches form a dense, ovoid or rounded crown.

LEAVES.—Alternate, simple, 5-6 inches long, 3-4 inches broad; obliquely heart-shaped; coarsely serrate; thick and firm; glabrous, dull dark green above, paler beneath; petioles slender, 1-2 inches long.

FLOWERS.—June-July, after the leaves; perfect, regular; yellowish white, downy, fragrant; borne on slender pedicels in loose, drooping cymes, the peduncle attached for half its length to a narrow, oblong, yellowish bract; sepals 5, downy; petals 5, creamy white; stamens numerous, in 5 clusters; ovary 5-celled; stigma 5-lobed.

FRUIT.—October; globose, nut-like, woody, gray, tomentose, about the size of peas.

WINTER-BUDS.—Terminal bud absent; lateral buds ovoid, acute, often lopsided, smooth, dark red, ¼ inch long.

BARK.—Twigs smooth, reddish gray, becoming dark gray or brown; dark gray and smooth on young stems, on old trunks thick, deeply furrowed into broad, scaly ridges. Plate VII.

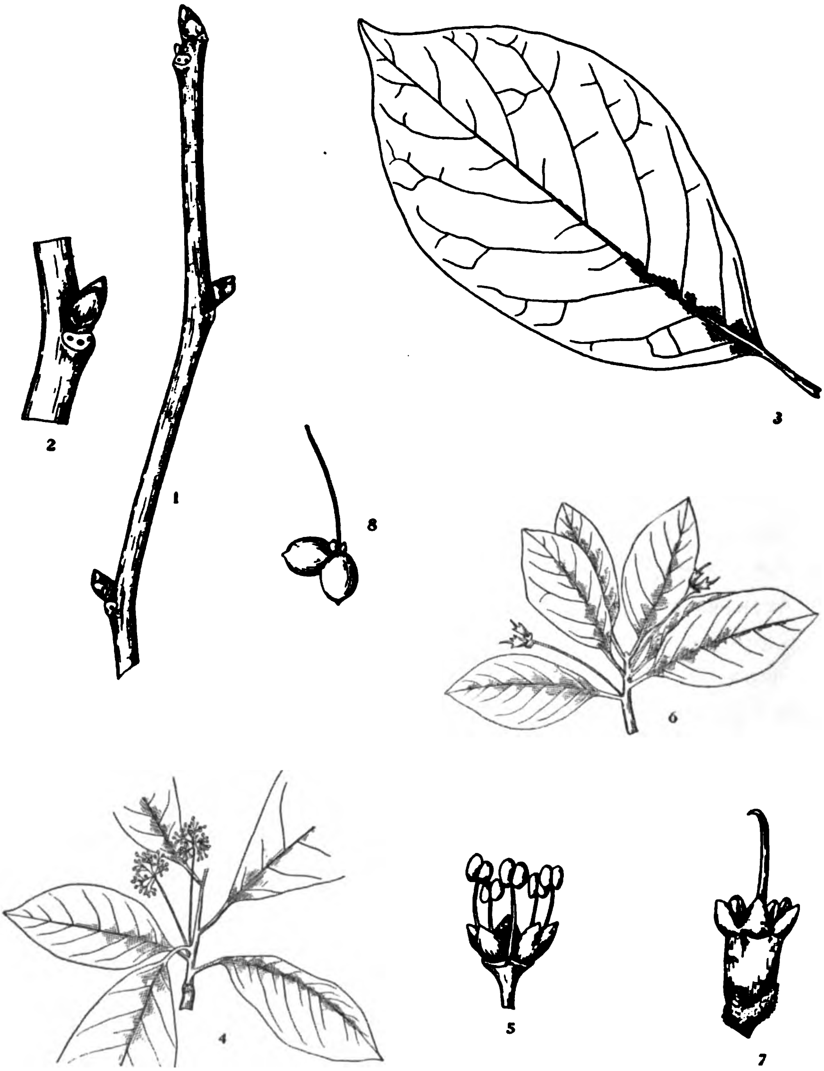
WOOD.—Light, soft, close-grained, tough, light red-brown, with thick sapwood of nearly the same color. Page 231.

DISTRIBUTION.—Common throughout Vermont at altitudes less than 1,000 feet, rare from 1,000-2,000 feet.

HABITAT.—Prefers rich, well-drained, loamy soils.

NOTES.—The basswood is a widely scattered tree in Vermont, growing with the maples, oaks and elms. Its leaves are five or six inches long and nearly as wide, with a base more deeply cordate on one side than the other. The flowers, which open in July, are creamy-white, borne in clusters suspended from a tongue-like leaf or bract. They are very fragrant and so full of nectar that the basswood often is called the bee-tree. The fruit ripens in autumn, forming hard brown balls or nutlets the size of peas. Basswood lumber is brownish or nearly white, light but rather tough, and is extensively used for drawers and similar cabinet work, panels, inside wood-work and for toys. Owing to the fact that it is bent readily, it is used for the bodies and dash boards of carriages and sleighs. The European linden (*T. europea*) occasionally is cultivated. It closely resembles the American species.

Black Gum. Tupelo



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ¾.
4. Staminate flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flowering branchlet, x ½.
7. Pistillate flower, enlarged.
8. Fruit, x ½.

CORNACEAE

Black Gum. Tupelo

Nyssa sylvatica Marsh. [Nyssa multiflora Wang.]

HABIT.—A medium-sized tree 20-40 feet high, with a trunk diameter of 1-2 feet, forming a rounded to cylindrical crown of slender, spreading, pendulous branches and a stiff, flat spray.

LEAVES.—Alternate, simple, 2-5 inches long, one-half as broad; oblong-obovate to oval; entire, or sometimes wavy-margined; thick and firm; very lustrous and dark green above, pale and often hairy beneath, turning bright scarlet, on the upper surface only, in autumn; petioles short.

FLOWERS.—May-June, with the leaves; polygamo-dioecious; greenish; borne on slender, downy peduncles; the staminate slender-pedicelled, in many-flowered heads; the pistillate sessile, in several-flowered clusters; calyx cup-shaped, 5-toothed; petals 5; stamens 5-10; stigma stout, terete, recurved.

FRUIT.—October; fleshy drupes, ovoid, blue-black, about ½ inch long, sour, in clusters of 1-3.

WINTER-BUDS.—⅛-¼ inch long, ovoid, obtuse, dark red.

BARK.—Twigs greenish or light brown, smooth or often downy, becoming smooth, dark red-brown; thick, red-brown on old trunks, deeply furrowed. Plate VIII.

WOOD.—Heavy, soft, strong, very tough, difficult to split, not durable in contact with the soil, pale yellow, with thick, whitish sapwood.

DISTRIBUTION.—Occasional along the shores of Lake Champlain and in the adjacent river-bottoms; also in southwestern Vermont; has been found in central Vermont as far north as Craftsbury.

HABITAT.—Prefers the borders of swamps and low, wet lands. Rarely flourishes in exposed situations.

NOTES.—The sour gum has a peculiar appearance with horizontal branches and smooth or glossy leaves, borne in beech-like sprays. Its greenish flowers appear in June and are followed by the dark-blue, egg-shaped fruits, one-half of an inch long, with thin, acid flesh, ripening in October. It is of great ornamental value when planted within its range.

THE ASHES

The olive family takes its name from the olive tree of Asia. The only representatives among our native trees are the ashes; but several of the commonly planted ornamental shrubs, the lilacs and other syringas and the beautiful forsythia, belong to this family.

The individual flowers of the ashes are small; but coming as they do before the leaves and appearing in crowded clusters, they are quite conspicuous. The flowers are of two kinds, the pollen producing and the seed bearing being on separate trees. The ashes, like the maples, have prominently winged fruit, but those of the ash hang singly whereas the maple "keys" are always in pairs.

The ashes are among the most useful of the hardwood forest trees of America, yielding to the oaks alone in value. Two species, the black ash and the white ash, occur commonly throughout Vermont, the red ash and the green ash are restricted or local in their distribution. The latter two are very similar and intermediate forms connect them so closely that some authorities rate the green ash as but a variety of the red ash. In using the following key it is to be observed that the ash leaf is compound, that is, each leaf is divided into from seven to eleven smaller leaflets, as will be seen by examining any of the figures.

SUMMER KEY TO THE SPECIES OF FRAXINUS

a. Lateral leaflets sessile .... **F. nigra,** p. 193.

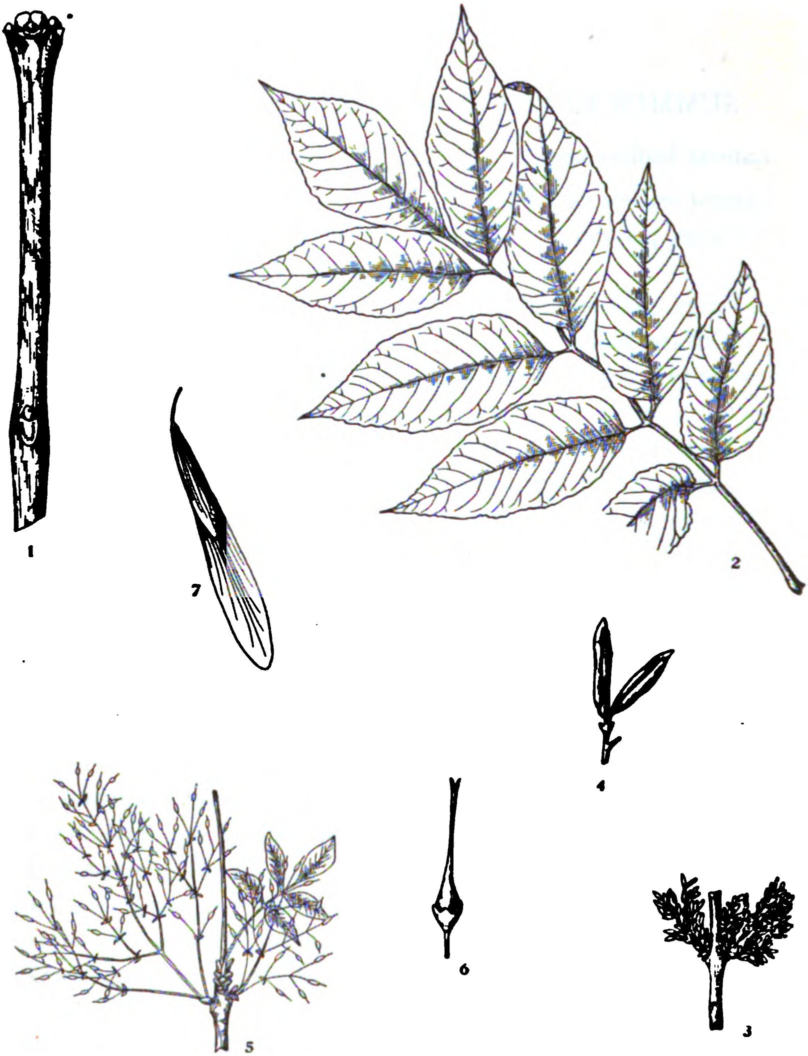
aa. Lateral leaflets petioled.
  b. Twigs, petioles and lower sides of leaves pubescent, **F. pennsylvanica,** p. 189.
  bb. Twigs, petioles and lower sides of leaves essentially glabrous.
    c. Lower sides of leaves essentially of the same color as the upper; leaflet-margins rather finely sharp-serrate, **F. pennsylvanica lanceolata,** p. 191.
    cc. Lower sides of leaves paler than the upper; leaflet-margins entire or obscurely serrate .... **F. americana,** p. 187.

WINTER KEY TO THE SPECIES OF FRAXINUS

a. Buds rusty-tomentose; twigs more or less downy, **F. pennsylvanica,** p. 189

aa. Buds not tomentose; twigs not downy.
  b. Terminal bud black or nearly so, showing 3 pairs of scales in cross-section; bud-scales apiculate at the apex; samaras with broad wings, the seed portion flattish; bark flaky, rubbing off on the hand .... **F. nigra,** p. 193.
  bb. Terminal bud brownish, showing 4 pairs of scales in cross-section; bud-scales rounded at the apex; samaras with narrow wings, the seed portion terete; bark ridged, not flaky and rubbing off on the hand.
    c. Upper margin of leaf-scars deeply concave, **F. americana,** p. 187.
    cc. Upper margin of leaf-scars not concave, but straight across or projecting upward..... **F. pennsylvanica lanceolata,** p. 191.

White Ash



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ¼.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x 1.

OLEACEAE

White Ash

Fraxinus americana L.

Habit.—A large tree 50-75 feet high, with a trunk diameter of 2-3 feet; forming an open, pyramidal crown of long, slender, lateral branches and a stout, rather sparse spray.

Leaves.—Opposite, pinnately compound, 8-12 inches long. Leaflets usually 7-9, 3-5 inches long, 1-2 inches broad; short-stalked; ovate to oblong-lanceolate; entire or obscurely serrate; thick and firm; glabrous, dark green above, paler beneath. Petioles glabrous, stout, grooved.

Flowers.—May, before the leaves; dioecious; borne in loose panicles on shoots of the previous season; calyx campanulate, 4-lobed; corolla 0; stamens 2, rarely 3; ovary 2-celled.

Fruit.—August-September, persistent on the branches until midwinter or the following spring; samaras 1-2 inches long, in crowded, drooping, paniculate clusters 6-8 inches long.

Winter-buds.—Short, rather obtuse; bud-scales apiculate, keeled, 4 pairs, rusty-brown.

Bark.—Twigs at first dark green, becoming gray or light brown, often covered with a glaucous bloom; gray, deeply furrowed into firm, narrow, flattened ridges on the trunk. Plate VIII.

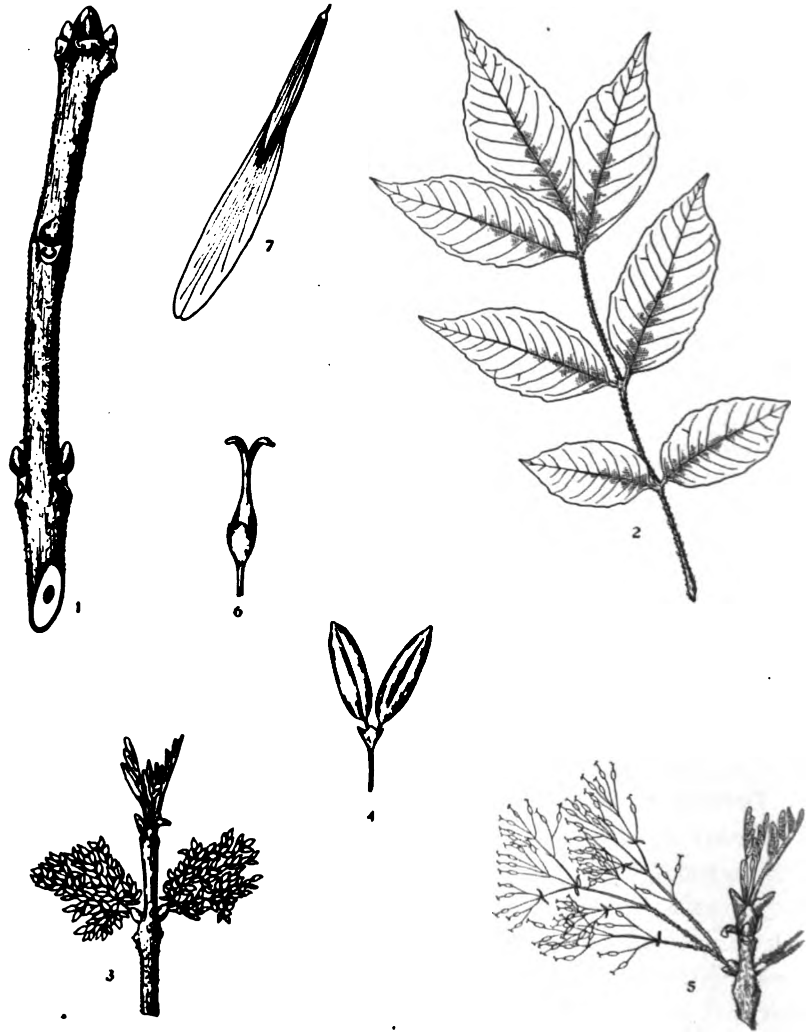
Wood.—Heavy, hard, strong, close-grained, tough, brown, with thick, lighter colored sapwood. Page 225.

Distribution.—Of common occurrence throughout Vermont.

Habitat.—Prefers a rich, moist, loamy soil, but grows in any well-drained situation; common along stream-beds.

Notes.—The white ash occurs in all parts of Vermont and upon all kinds of soil, but it prefers a rich, moist location. It is an open spreading tree in the field but in the forest it sends up a clean, straight shaft with a very small head. This character helps to make the white ash one of the valuable timber trees of our forests. The wood is strong, tough, elastic, durable and easily worked. It is manufactured into casings, every kind of furniture, agricultural implements and parts of carriages. It is said that in strength and elasticity the white ash timber from Vermont is superior to that from most other sources. The white oak and the hickories are the only native trees which have a higher value for fuel. This ash is recognized by its compound leaves, nearly twelve inches long, with from seven to nine smooth, petioled leaflets.

Red Ash



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅓.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x 1.

OLEACEAE

Red Ash

Fraxinus pennsylvanica Marsh. [Fraxinus pubescens Lam.]

HABIT.—A medium-sized tree 30-50 feet high, with a trunk diameter of 1-2 feet; stout, upright branches and slender branchlets form a compact, broad, irregular crown.

LEAVES.—Opposite, pinnately compound, 10-12 inches long. Leaflets 7-9, 3-5 inches long, 1-1½ inches broad; short-stalked; oblong-lanceolate to ovate; slightly serrate or entire; thin and firm; glabrous, yellow-green above, pale and silky-downy beneath. Petioles stout, pubescent.

FLOWERS.—May, with the leaves; dioecious; borne in compact, downy panicles on shoots of the previous season; calyx cup-shaped, 4-toothed; corolla 0; stamens 2, rarely 3; ovary 2-celled.

FRUIT.—Early autumn, persistent on the branches throughout the winter; samaras 1-2 inches long, in open, paniculate clusters.

WINTER-BUDS.—Small, rounded; bud-scales rounded on the back, 3 pairs, rusty brown, tomentose.

BARK.—Twigs pale pubescent at first, lasting 2-3 years or often disappearing during the first summer, finally ashy gray or brownish and often covered with a glaucous bloom; brown or dark gray on the trunk, with many longitudinal, shallow furrows; somewhat scaly.

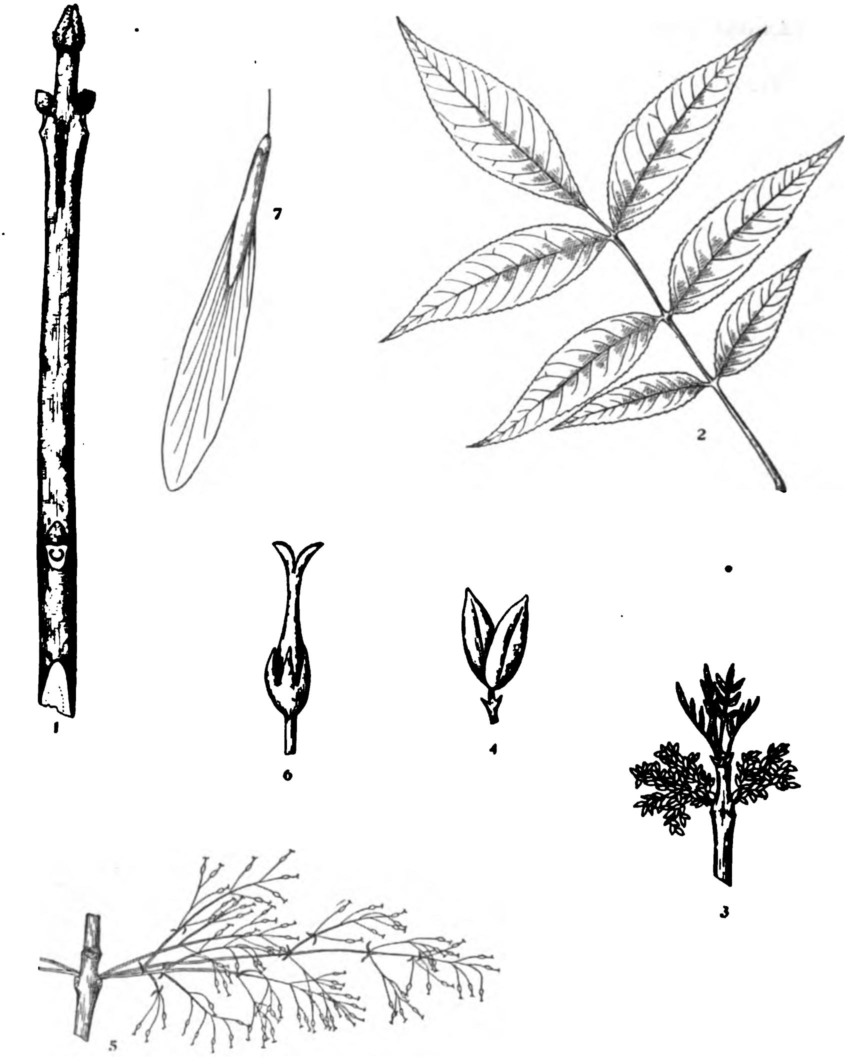
WOOD.—Heavy, hard, strong, brittle, coarse-grained, light brown, with thick, yellow-streaked sapwood.

DISTRIBUTION.—Common along Lake Champlain and its tributaries; occasional in other sections.

HABITAT.—Wet or moist, rich loam; river-banks; swampy lowlands.

NOTES.—The red ash closely resembles the white ash in general appearance. It may be recognized always, however, by looking closely at the buds in winter or at the young shoots or petioles in summer. These parts are velvety with delicate hairs, and it is this characteristic pubescence which suggested the Latin name of the species. The flowers and fruits bear a general resemblance to those of the white ash. The red ash is used considerably in manufactures but is inferior to the preceding species for most purposes. It is distributed generally along the shores of Lake Champlain and its adjacent waters but has not been reported from other parts of Vermont.

Green Ash



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅓.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x 1.

OLEACEAE

Green Ash

Fraxinus pennsylvanica lanceolata (Borkh.) Sarg. [Fraxinus lanceolata Borkh.] [Fraxinus viridis Michx. f.]

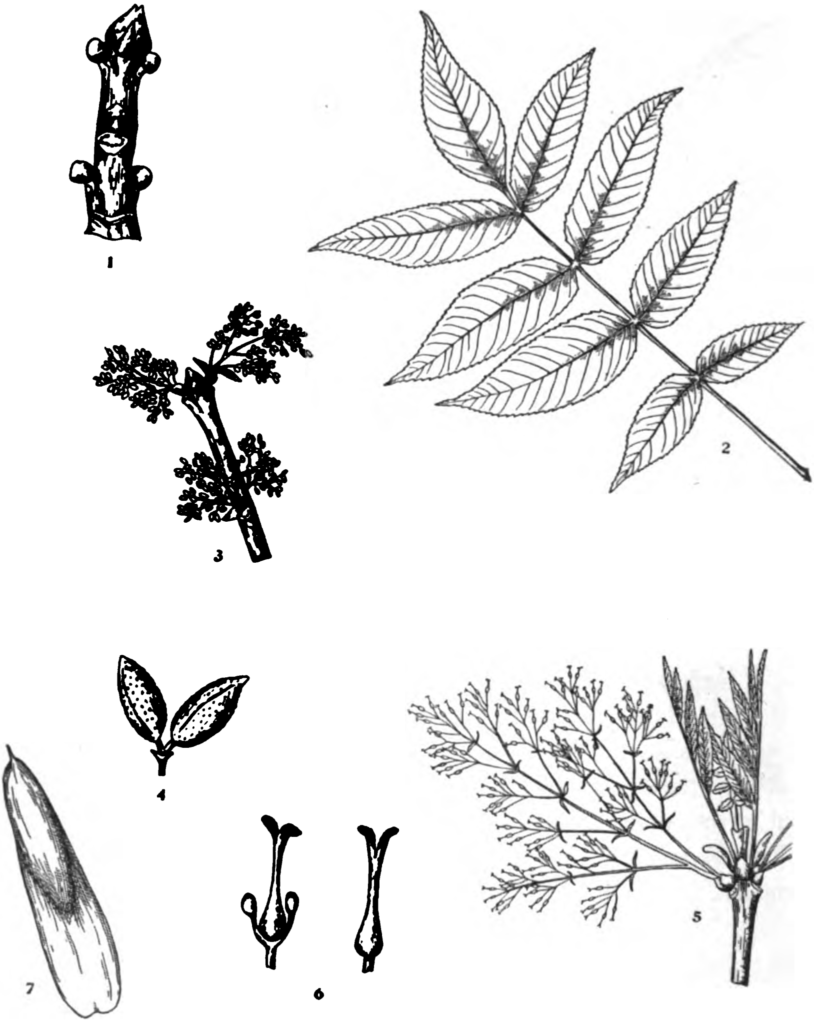
Considered by some authors to be a distinct species, and by others a variety of *F. pennsylvanica Marsh.*, which it resembles. The main points of difference are:

> The usual absence of pubescence from the branchlets, the under side of the leaflets, and the petioles.
>
> The rather narrower, shorter, and more sharply serrate leaflets.
>
> The color of the leaves, which is bright green on both sides.

A very hardy tree, of rapid growth and desirable habit, making it useful for ornamental and street planting. Easily transplanted.

The green ash occurs occasionally along the shores of Lake Champlain.

Black Ash



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅓.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flowers, enlarged.
7. Fruit, x 1.

OLEACEAE

Black Ash

Fraxinus nigra Marsh. [Fraxinus sambucifolia Lam.]

HABIT.—A tall tree 60-80 feet high, with a trunk diameter of 1-2 feet; slender, upright branches form in the forest a narrow crown, in the open a rounded, ovoid crown.

LEAVES.—Opposite, pinnately compound, 12-16 inches long. Leaflets 7-11, 3-5 inches long, 1-2 inches broad; sessile, except the terminal; oblong to oblong-lanceolate, long-pointed; remotely, but sharply serrate; thin and firm; dark green above, paler beneath, glabrous. Petioles stout, grooved, glabrous.

FLOWERS.—May, before the leaves; polygamo-dioecious; borne in loose panicles on shoots of the preceding season; calyx 0; corolla 0; stamens 2; ovary 2-celled.

FRUIT.—August-September, falling early, or sometimes hanging on the tree until the following spring; samaras 1-1½ inches long, in open, paniculate clusters 8-10 inches long.

WINTER-BUDS.—Ovoid, pointed; bud-scales rounded on the back, 3 pairs, almost black.

BARK.—Twigs at first dark green, becoming ashy gray or orange, finally dark gray and warted; thin, soft ash-gray and scaly on the trunk. Bark flakes off on rubbing with the hand. Plate VIII.

WOOD.—Heavy, tough, coarse-grained, weak, rather soft, dark brown, with thin, lighter colored sapwood.

DISTRIBUTION.—Common throughout the lower altitudes.

HABITAT.—Deep, cold swamps and low river-banks; wet woods.

NOTES.—The black ash is found in lowlands and swamps. Often it is called the brown ash but this name is confusing as it is applied also to the red ash. This and the white ash are the commoner species of Vermont. They are distinguished easily by the fact that the leaflets of the white ash always are distinctly stalked while the black ash has sessile leaflets. These are seven to eleven in number, often forming a leaf twelve to sixteen inches long which is smooth and green on both sides. Black ash timber is coarser-grained than is that of white ash. It is used for furniture and interior finishings and in the manufacture of baskets.

THE STRUCTURE AND IDENTIFICATION OF OUR COMMON LUMBER WOODS

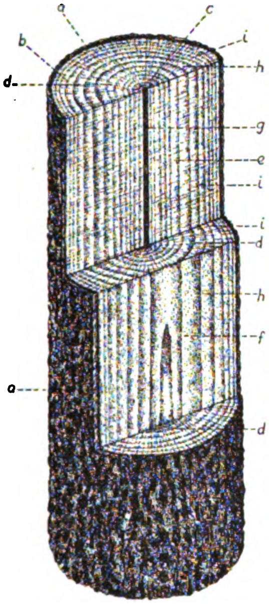
By C. H. OTIS

Common as wood is in its varied forms and uses, comparatively few people are able to distinguish our familiar trees when sawed into lumber and fashioned into houses, furniture and other manufactured products. Yet each wood has characteristics of color, odor, graining, weight, hardness, strength and minute structure peculiar to itself which distinguish it from other woods.

The value of each kind of wood for building purposes and every other use is determined to a large extent by its characteristics. These, taken in connection with the available supply of any particular timber in the country, govern the value or cost of that timber in the lumber market. So certain trees, like oak and cedar, because of their durability in contact with the soil, make admirable fence posts; spruce and the broad-leaved white birch and cottonwood possess structural qualities adapting them to the manufacture of paper pulp; hickory, very strong, tough and straight-grained, has long been valued for carriage and wagon stock and tool handles. Many examples might here be cited to show how various woods are peculiarly adapted to certain uses to a greater extent than are others. Again, some species, on account of our wasteful methods of lumbering, failure to provide means of reproduction and lack of restriction as to particular uses, have become so scarce that substitutes are offered in the markets to take their places. To such an extent has this become true that methods are in use to imitate the grain and color of some of the more depleted but valuable woods. Thus birch enters very largely into the composition of a great deal of so-called modern mahogany furniture, and cheap woods are often grained to imitate quarter-sawed white oak.

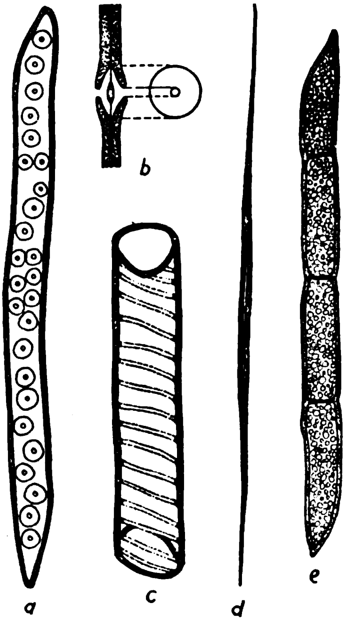
With the great variety of useful woods to be found in any lumber yard, it is important that consumers of wood in any form should be able to identify the different kinds offered so that they may choose those woods best suited to their particular needs and that they may obtain them and not lumber similar in appearance but otherwise of inferior qualifications.

Wood structure and the arrangement of the elements making up the woody tissues constitute the basis of the identification and use of timber. By structure is meant the relative size, shape and form of the wood elements peculiar to each tree. It is by reason of their structure that some woods are heavier, stronger and stiffer than others, that some are straight- and others are cross-grained, that some are hard and some soft and that some season rapidly and without injury while others have a tendency to check and split. The wide medullary rays of the oak explain the pleasing effect of the wood when quarter-sawed and polished to bring out the grain. The peculiar undulations of the growth rings sometimes found in the maple produce the "bird's-eye" markings which make the lumber so prized in the manufacture of furniture. It is our purpose to consider briefly the structure of a tree trunk and the various elements of the woody tissues.



VIII. LOG CUT TO SHOW FEATURES.

a. **Bark.**
b. **Sapwood.**
c. **Heartwood.**
d. **Cross-section.**
e. **Radial-section.**
f. **Tangential-section.**
g. **Pith.**
h. **Growth ring.**
i. **Medullary ray.**



IX. TYPICAL WOOD ELEMENTS, DIAGRAMMATIC. GREATLY ENLARGED.

a. **Tracheid, showing bordered pits.**
b. **Scheme of bordered pit in section and surface views.**
c. **Segment or single cells of a vessel, showing spiral thickenings.**
d. **Wood or bast fiber.**
e. **Group of wood-parenchyma cells.**

If we should go into a forest where felling operations are in progress or into a sawmill where there are unsawed logs, we would have an opportunity to examine the smooth-cut end of a mature log. We would note that it exhibits several well-defined areas or layers.

The first layer on the outside is probably rough externally and dark-colored. This is the bark, (a, fig. VIII), a protective covering to the inner woody tissues. The outer portion of the bark of a forest tree is dead tissue which is stretched and fissured as the tree grows in diameter, while the inner portion is live tissue, serving to conduct food materials up and down the trunk. In some kinds of trees the bark is quite thick, in others very thin. This factor, together with those of color and external appearance, makes the bark, when present, of considerable value in the determination of woods. At the center of the log is a small cylinder of loose tissue less than one-fourth of an inch in diameter, the pith (g, fig. VIII). Lying between the bark and the pith is the wood. In some kinds of trees, like the balsam fir and the hemlock, the wood is all of one color. In others, it consists of two parts distinct from each other in color. The outer portion is called sapwood (b, fig. VIII). It is living tissue and serves chiefly in the living tree to conduct the sap, or water which is taken up by the roots, to the leaves. The width of the sapwood varies with different species and with different individuals of the same species. In very young trees all the wood is sapwood. As the sapwood grows older, the tissue composing it becomes choked so as to prevent the further passage of sap. This tissue then dies and serves only as a support to the rest of the tree, holding up its great weight and making it rigid enough to resist strong winds. It usually becomes darker colored than the sapwood, and is called heartwood (c, fig. VIII). The sapwood and heartwood differ not only in color, but also in durability. In some species only the heartwood is suitable for sawing into lumber, being, as a rule, harder, heavier and drier than sapwood. In other cases where pliability or elasticity is required, as, for example, in hickory and ash which are used in making baskets or for handles of rakes, hoes and golf clubs, the sapwood is more valuable than the heartwood.

Separating the wood from the bark is a very thin layer, the cambium. From this layer is added new wood on the outside of that already formed and new bark on the inside of the old bark. It is by this process that the trunk grows in diameter. Each year the cambium adds a new layer of wood to the circumference of the tree. These layers appear on the end of the log as concentric rings. They are called annual, yearly or growth rings (h, fig. VIII). In maple, birch, white pine and many other woods there is no sharp distinction between the wood formed in the spring and that formed in summer. In other cases the wood which is formed in the spring, when growth is most rapid, differs in nature from the harder and denser wood formed later in the season. The oaks, elms and hickories present clearly defined layers. The two layers are called early or spring wood and late or summer wood. The presence or absence of well-defined spring and summer wood is an important factor in distinguishing and naming the different woods; in fact, the grain or figure of some kinds of lumber depends entirely upon the difference between spring and summer wood.

Radiating from the center of the trunk toward the bark, like the spokes of a wheel, are slender but more or less distinct lines. These are the medullary rays (i, fig. VIII). Medullary rays serve two functions; they are paths for the conduction of food materials between bark and wood or wood and bark, and they bind the trunk together from pith to bark. Woods differ in the size and number of medullary rays present, the rays being inconspicuous in some and very prominent in others. If an oak log be cut along any of its many radii, i. e., parallel to one of the lines of the medullary rays, the beautiful "flakes" of the quarter-sawed oak are exposed to view. In other trees, like the maples, the medullary rays may be so small as to escape notice. But whether prominent or inconspicuous, the medullary rays help largely to make up the pattern which often readily and surely distinguishes one wood from another.

We have learned from our superficial inspection that a tree is not a simple structure but a complex organism composed of several kinds of tissues, each having its particular function in the life of the tree. In order to continue our study further, it is necessary that we use a hand lens or a compound microscope. If we examine the smoothly cut end of a piece of wood, or, better, a very thin shaving, we find that it is seemingly made up of a network of holes or pores held together by chains of solid tissue, in appearance resembling the chambers of a honeycomb. All trees, all tissues composing trees, are made up of millions of these units, just as a wall is built of bricks and mortar. These units making up the bodies of trees are called cells (fig. IX). A cell may be considered in the nature of a box, but so small is it that it is usually indistinguishable to the naked eye. The walls of the box or cell are composed for the most part of a woody substance called cellulose; we call them cell-walls. In young cells, such as we find in the actively growing parts of trees, the whole cavity of the cell is filled with a slimy substance called protoplasm. The protoplasm is the living substance of the tree; where there is protoplasm, there is life and growth. As the cells grow older and larger, the protoplasm does not continue to fill the whole cavity within the cell-walls, but forms only a thin lining around the walls. Finally it disappears altogether, leaving the dead cell-walls intact, making the substance called wood. The cells composing wood are not all the same shape or size, but vary greatly according to the function which they serve in the life of the tree. Because of the great variety of the cells composing it, wood takes on various characters of structure, graining and coloring, which are distinctive for each kind of wood and which greatly aid in distinguishing the various kinds from one another.

The wood of conifers is very regular and simple, consisting mainly of cells of one sort. It is this uniformity of structure which makes the wood of conifers valuable for so many purposes. These cells are called tracheids (a, fig. IX). They are vertical, elongated, tapering tubes, one-twentieth to one-fifth of an inch in length, with closed ends and a relatively large cavity. The pointed ends of the tracheids overlap one another in a dovetailed fashion, breaking the joints and making the wood much stronger than it would be otherwise. They are further identified by the presence of pits or pores in their walls which serve as waterways between the tubes. These pits (b, fig. IX) appear as if made up of two circles, and they are for this reason called bordered pits. The other cells making up the wood of conifers are the ray cells. These extend horizontally, and in a radial-section appear as tiers of regular, brick-shaped cells. The cells communicate with one another by numerous pits in the walls. In certain genera the medullary rays are bordered by tracheids similar to the ordinary wood tracheids, but designated as ray tracheids. In one of the pines the ray tracheids have teeth-like projections from the walls, which are useful in identifying this species. Scattered here and there on the cross-section of some coniferous woods are to be seen irregular grayish or brownish dots. These are resin ducts and are especially well-represented in the pines. Resin ducts are openings between cells containing resin, which is manufactured by certain trees. If you cut a limb from a pine tree, the cut surface will very quickly become sticky with the resin which oozes from these ducts. On a warm day in the pine woods the resin is quite apparent by its fragrant odor. Some woods have present also certain cells or groups of cells which produce resin, which gives them a distinctive appearance, and therefore they are called resin cells. Their presence or absence aids in the determination of certain woods.

The wood of broad-leaved trees is much more complex in structure than the wood of conifers. Instead of being made up essentially of one kind of cells, tracheids, as is the case in the coniferous woods just mentioned, the wood of broad-leaved trees is composed of several kinds of cells. If we examine the cut end of a red oak branch we notice that the spring wood contains many comparatively large openings which are visible even to the naked eye. These openings are called pores; they are cross-sections of open tubes or vessels or tracheae which run up and down the trunk of the tree and out into the branches and twigs. In the beginning they resembled the tracheids of conifers, i. e., they were made up of separate and distinct cells. Later, the end walls of the cells which met endwise were absorbed, leaving a continuous series of connected cells or a tube (c, fig. IX). These tubes or vessels serve in the living tree as water-carriers. For the sidewise conduction of fluids, the vessels are usually abundantly pitted with bordered pits, but the pits are somewhat smaller than those commonly found in the tracheids of coniferous woods. Furthermore, it is very common for vessels, especially the smaller ones, to be marked with spiral thickenings on their interior walls. The scalariform perforations present in the end partitions of the vessels of a few woods, as seen on the radial-section, are sometimes confused with the true spiral thickenings just mentioned. This point may be definitely determined by an inspection of tangential- as well as radial-sections. Tyloses also occur in the vessels of many of the broad-leaved woods, sometimes being visible to the naked eye. Tyloses are usually rather thin-walled cells which protrude into the cavities of the vessels, where they divide rapidly and grow, sometimes filling the entire cavity and plugging the vessels so as to prevent further conduction of fluids. The value of white oak for cooperage is increased by tyloses, which are especially abundant in the vessels of this wood. They are also well-represented in the locust, in this instance being rather thick-walled.

It is convenient to divide broad-leaved woods into two groups, which are characterized by the size and arrangement of the vessels. In some species of wood the vessels which are formed later in the season are much smaller than those formed earlier. A wood of this kind, with its large pores collected into a row or band in each growth ring, is spoken of as ring-porous. In other woods, the pores are more nearly uniform in size in both spring and summer wood. They are designated as diffuse-porous woods. The wood of the maple is of this character. In many of the diffuse-porous woods the pores are too small to be seen with the naked eye, and in some cases they may even be indistinct when viewed with a lens. They should not, however, because of this, be confused with the non-porous coniferous woods, which they may resemble.

Tracheids in the wood of broad-leaved trees are subordinate elements. They are much smaller and less uniform in size and shape than in conifers and are more abundant in the vicinity of the tubes or vessels. As in conifers, the tracheids bear numerous bordered pits on their walls. In some cases, as in the wood of the ash, tracheids are absent.

Strength, hardness and toughness are given to broad-leaved woods principally by the wood fibers. These are slender, spindle-shaped, sharp-pointed cells with thick walls and narrow cavities (d, fig. IX). Usually they are provided with oblique, slit-like, simple pits. The wood fibers for the most part lie vertically side by side and parallel to one another, but in some woods, like the sycamore, they are more or less interwoven. This makes the wood cross-grained, difficult to work and hard to split.

While the medullary rays of coniferous woods are uniformly small and inconspicuous, they are often broad and prominent in broad-leaved woods. They are largest in the oak, where they may become twenty-five to seventy-five cells wide and several hundred cells high; between these broad rays are numerous smaller ones, mostly uniseriate and from one to twenty cells high. In the sycamore all the rays are broad, while in the beech only a portion of the rays are broad. Ray cells are usually elongated in the radial or horizontal direction and are then termed procumbent. Not infrequently, however, the marginal cells, as in the willow, are elongated vertically; cells of this kind are said to be upright. These differences in the character of the medullary rays are important means of identification.

Another kind of tissue which is more or less prominent in broad-leaved woods is wood parenchyma. Parenchyma consists of vertical groups of short cells, the end ones of each group tapering to a point (e, fig. IX). The cells of parenchyma resemble the cells of the medullary rays; the walls are invariably pitted with rounded, simple pits. The function of the parenchyma is the distribution and storage of the food products manufactured by the leaves. The distribution of parenchyma on the cross-sections of different species is subject to more or less variation, making this feature of considerable importance in classifying woods. Commonly wood parenchyma is grouped around the pores or vessels. In the basswood it occurs in somewhat broken, tangential lines, forming, with the wood fibers, a tier-like arrangement of the wood elements. In the hickory it forms numerous, fine, concentric lines which are as distinct as the rays. In other woods it may be confined to several rows of cells at the outer limit of the growth ring.

As a final feature having some value in the identification of certain of the woods, is to be mentioned the so-called "pith flecks". They are common in many of our native woods, appearing as crescent-shaped, discolored patches on the cross-section and as brownish streaks running up and down the stem in longitudinal-section. Pith flecks are not a special kind of tissue, but are tunnels made by the larvae of a two-winged insect which lives in the cambium during the growing season. These pith flecks have been found to occur in only five families of trees in the United States, namely, the willow, birch, rose, maple and linden families. They are by no means constant in their occurrence; some stems have numerous pith flecks, while other stems of the same species from the same vicinity do not have them. Taken in conjunction with other characters, however, the presence of pith flecks in considerable numbers may aid in the identification of woods.

The subject of wood structure is one of absorbing interest to one who will but take a little trouble to go beneath the surface. Facts will be revealed which have hitherto lain hidden because of our usual cursory method of handling wood. Some practise may be necessary at first, a little patience may be needed at times, but success will be the reward of honest effort. In all identification work a very sharp knife is necessary. Surfaces must be cut cleanly and smoothly, keeping always in mind that a bruised and broken surface reveals but little of the structure of the wood. Large pieces are not essential, even small cuts along the edge will often suffice. Twigs cut easier than seasoned boards and are frequently as instructive as the more mature wood. Wetting the cut surface will usually make the structural features more prominent. Instructive sections may be made with a very sharp knife or razor, or even with a plane, by cutting very thin pieces and mounting them in water or glycerin between two thin pieces of glass. The sections may even be colored to advantage by soaking them for a time in a dye, thus making certain features more evident. Transparent water colors such as are used in coloring photographs and prints are generally available and will be found to serve as well as the usual laboratory stains. The mounts may be examined with a hand lens by holding them between the eye and the light, or they may be viewed with a compound microscope. If the latter is employed, the sections of wood must be cut very thin and the customary thin cover-glass must be used between the wood-section and the microscope lens.

In the key to the woods which follows, it will be noticed that two large divisions have been made, one the porous woods, being the great mass of broad leaved woods, the other the non-porous or coniferous woods. Porous woods have again been divided into two groups, the ring-porous woods and the diffuse-porous woods. The key is constructed on the same principles which have been employed throughout in other keys in this bulletin. For an explanation and illustration of the manner of using a key, the reader is referred to the chapter on "Artificial Keys, How Made and Used" (pages 13 to 15). Attention is called to the fact that both naked-eye and microscopic characters have been introduced into the key to the woods. Naked-eye characters are printed in Roman type, the microscopic in italics. While keys based solely upon naked-eye or macroscopic characters have been published, their use often leads the beginner to wrong conclusions or utter confusion. The insertion of microscopic characters may be considered, then, as a necessary affliction which has been imposed to make accurate determinations easy, rather than to complicate the key. The more common or important woods have been illustrated by cross-, radial- and tangential-sections of the woods. In the preparation of these drawings, photomicrographs of very thin, stained sections of typical wood were taken. Blueprints were subsequently made from the negatives and the outlines of the cells were drawn in with India ink. Finally the prints were bleached, the result being a silhouette of the original wood-section drawn accurately to a scale on a white background.

KEY TO THE WOODS OF VERMONT

In the following key, the Roman type calls attention to characters which may readily be distinguished by the naked eye or by the use of a hand lens, and should not be interpreted as indicating more important characters. The italics represent characters that can be studied only with a compound microscope.

The word in parenthesis indicates the section, cross-, radial-, tangential- or longitudinal-, which shows the point in question to greatest advantage.

a.[1] Pores (cross) visible and conspicuous, at least with magnifier, *i. e., wood composed of three to six kinds of cells, which are not uniform in structure and usually not arranged in definite radial rows;* resin ducts and resin cells (cross) absent; rays (cross) for the most part conspicuous.

b. Growth rings (cross) defined by zones of large pores in the spring wood alternating with the denser summer wood; pores in summer wood small, or few and scattered.

c. Rays (cross), or part of them, broad, easily distinguishable by the naked eye at three feet distance; on close inspection, rays of two kinds, broad and fine.

d. Pores (cross) abruptly diminishing in size from spring wood to summer wood; *tyloses (longitudinal) present, usually abundant in all large pores.*

e. Pores (cross) of spring wood 1-3 rows deep.

f. Pores (cross) of summer wood arranged chiefly in single, radial rows, seldom joined tangentially, the rows extending to the periphery of the growth rings,

Quercus bicolor.

ff. Pores (cross) of summer wood arranged chiefly in double, radial rows, often joined tangentially, the rows rarely extending to the periphery of the growth rings.

g. Radial rows of summer-wood pores (cross) relatively wide; large rays about ¼ inch apart,

Quercus macrocarpa.

gg. Radial rows of summer-wood pores (cross) relatively narrow; large rays about ⅛ inch apart,

Quercus alba.

ee. Pores (cross) of spring wood 3-5 rows deep.

f. Radial rows of small pores (cross) chiefly in several rows, becoming wider toward the periphery of the growth rings; walls of summer-wood pores thin,

Quercus prinus.

---

[1] *aa.* See page 211.

ff. Radial rows of small pores (cross) chiefly in one row, becoming narrower toward the periphery of the growth rings; walls of summer-wood pores thick, **Quercus muhlenbergii.**

dd. Pores (cross) gradually diminishing in size from spring wood to summer wood; *tyloses (longitudinal) usually scarce or wanting.*

e. *Wood-parenchyma cells (cross) arranged in concentric lines around the pores;* heartwood red-brown, **Quercus velutina.**

ee. *Wood-parenchyma cells (cross) grouped irregularly around the pores;* heartwood light red, **Quercus rubra,** p. 230.

cc. Pores (cross) all fine, indistinguishable by the naked eye at three feet distance; on close inspection, rays of one kind, all fine.

d. Pores (cross) of summer wood small and inconspicuous, or when visible single, grouped, or forming short, broken lines, but never forming extended radial or tangential lines.

e. Rays (cross) clearly distinct to the naked eye at 6-12 inches distance; growth rings for the most part wide to very wide; rays (radial) very high and prominent.

f. Pores (cross) of late summer wood in large groups *of 6-many, joined tangentially by wood parenchyma,* often forming tangential lines plainly visible to the naked eye at a distance of 6-12 inches; *tyloses (tangential) very abundant, densely plugging the vessels;* wood yielding a brown stain when rubbed with a wet, white handkerchief..........**Robinia pseudo-acacia.**

ff. Pores (cross) of late summer wood in small groups *of 3-6, not joined tangentially by wood parenchyma,* never forming tangential lines which are plainly visible to the naked eye at a distance of 6-12 inches; *tyloses (tangential) only fairly abundant, never plugging the vessels;* wood not yielding a brown stain when rubbed with a wet, white handkerchief.......**Morus rubra.**

ee. Rays (cross) not clearly distinct to the naked eye at 6-12 inches distance, inconspicuous to microscopic; growth rings (cross) for the most part narrow; rays (radial) not high and prominent.

f. Pores (cross) of summer wood *solitary, rarely grouped,* not forming short, tangential lines; wood parenchyma (cross) forming more or less continuous, tangential lines as distinct, or nearly so, as the rays; *tyloses* (*tangential*) *present* .... **Carya,** p. 229.

ff. Pores (cross) of summer wood *usually grouped,* for the most part forming short, tangential lines; wood parenchyma (cross) not forming continuous, tangential lines; *tyloses* (*tangential*) *absent.*

g. Pores (cross) of spring wood 1-2 rows deep, forming a narrow zone not over one-fourth the width of the growth ring.. **Fraxinus, pennsylvanica lanceolata.**

gg. Pores (cross) of spring wood 3-5 rows deep, forming a broad zone one-third to one-half the width of the growth ring.

h. Pores (cross) of summer wood *joined by wood parenchyma,* forming short or more or less extended, tangential lines; wood hard and strong.

i. Lines of pores and wood parenchyma (cross) in summer wood short and broken, mostly near the periphery of the growth ring (*occasionally absent or very indistinct*)..**Fraxinus americana,** p. 225.

ii. Lines of pores and wood parenchyma (cross) in summer wood long, more or less extended, usually well distributed through the growth ring................**Fraxinus pennsylvanica.**

hh. Pores (cross) of summer wood *not joined by wood parenchyma,* rarely forming tangential lines; wood soft and weak............**Fraxinus nigra.**

dd. Pores (cross) of summer wood small, but distinct, grouped or more or less confluent, or joined by wood parenchyma, to form wavy or branching, more or less extended, radial or tangential lines.

e. Pores (cross) of summer wood arranged in radial, branching lines (when very crowded, radial arrangement somewhat obscured); pores (cross) of spring wood plainly visible to the naked eye at a distance of two feet, *strongly oval or elliptical,* occupying nearly half the growth ring......................**Castanea dentata.**

ee. Pores (cross) of summer wood arranged, ***or joined by wood parenchyma,*** to form wavy or branching, tangential lines; pores (cross) of spring wood not plainly visible to the naked eye at a distance of two feet, ***not strongly oval nor elliptical,*** not occupying nearly half the growth ring.

f. Lines of summer-wood pores (cross) strongly wavy; ***tyloses (tangential) mostly absent, not densely plugging the vessels;*** wood not yielding a brown stain when rubbed with a wet, white handkerchief; growth rings (cross) not very wide.

g. Pores (cross) of spring wood in 3-many rows; pores (cross) of summer wood small, forming thin, rather broken and disconnected, tangential lines, not strongly wavy; heartwood chocolate-brown, **Ulmus fulva.**

gg. Pores (cross) of spring wood usually in a single row, or nearly so; pores (cross) of summer wood large, forming broad, mostly connected, tangential lines, strongly wavy; heartwood light brown or red.

h. Pores (cross) of spring wood large, plainly visible to the naked eye at a distance of 6-9 inches, forming a continuous row; texture coarse; wood hard to split .... **Ulmus americana,** p. 225.

hh. Pores (cross) of spring wood small, not visible to the naked eye at a distance of 6-9 inches, not forming a continuous row, but the larger ones few and rather widely separated; texture medium; wood fairly easy to split............ **Ulmus racemosa.**

ff. Lines of summer-wood pores (cross) not strongly wavy; ***tyloses (tangential) present, densely plugging the vessels;*** wood yielding a brown stain when rubbed with a wet, white handkerchief; growth rings (cross) very wide .... **Robinia pseudo-acacia.**

bb. Growth rings (cross) not defined by zones of large pores in the spring wood, but pores all the same size, or nearly so, scattered more or less evenly through the growth ring, occasionally more numerous and very often somewhat larger in the spring wood.

c. Rays (cross) usually plainly visible to the naked eye at a distance of 6-9 inches.

d. Rays (cross) uniform, all of them more or less equal in size (see note below[1]).

e. Wood-parenchyma cells (cross) forming continuous or somewhat broken, tangential lines or bands, scarcely visible with a lens; wood light and soft.

f. Wood elements (cross) alternating with parenchyma elements in a tier-like arrangement; *vessels (tangential) with spirals; rays (tangential) very narrow, slender-tapering;* color light brown to nearly white, **Tilia americana,** p. 231.

ff. Wood elements (cross) not alternating with parenchyma elements in a tier-like arrangement, *but confined to 2-4 rows of flattened cells at the outer limit of the growth ring; vessels (tangential) without spirals; rays (tangential) rather wide, abruptly-tapering;* color bluish to the more common yellow-brown, often striped ....**Liriodendron tulipifera.**

ee. Wood-parenchyma cells (cross) not forming tangential lines or bands; wood moderately heavy and hard.

f. *Ray cells (radial) about as long as high; vessels (longitudinal) plugged at intervals with dark red gum;* color rich red-brown or wine.

g. Rays (cross) distinct to the naked eye; pith flecks (cross) usually absent; pores (cross) large and conspicuous under a hand lens.

h. Pores (cross) of the spring wood larger and more numerous than those of the summer wood; *larger rays (tangential) 3-4-seriate;* wood rather soft, **Prunus nigra.**

hh. Pores (cross) of the spring wood not noticeably larger nor more numerous than those of the summer wood; *larger rays (tangential) 6-8-seriate;* wood rather hard.............**Prunus serotina.**

gg. *Rays* (cross) barely visible to the naked eye; pith flecks (cross) usually present, often prominent; pores (cross) rather small and inconspicuous, even under a hand lens.........**Prunus pennsylvanica.**

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[1] The genus *Crataegus* apparently belongs here; but the wood varies so greatly and is of so little importance commercially that no attempt has been made to incorporate it within the key.

ff. *Ray cells* (*radial*) *about twice as long as high; vessels* (*longitudinal*) *not plugged at intervals with dark red gum;* color light brown to reddish.

g. Wood cream-white, without reddish tinge; rays (radial) not conspicuously darker than surrounding wood; growth rings (cross) usually very wide,

Acer negundo.

gg. Wood light red-brown to decidedly reddish; rays (radial) conspicuously darker than surrounding wood; growth rings (cross) usually moderately wide to narrow.

h. Larger rays (*tangential*) *4-6-seriate,* for the most part broader than the pores (cross); pith flecks absent or rare; growth rings more or less distinct; wood very heavy and hard,

Acer saccharum, p. 223.
Acer saccharum nigrum.

hh. Larger rays (tangential) *2-3-, or occasionally 4-seriate,* mostly narrower than the pores (cross); pith flecks present, often abundant; growth rings for the most part indistinct; wood rather light and soft.

i. Pores (cross) barely visible to the naked eye with close scrutiny; pith flecks (cross) usually small, neither abundant nor conspicuous,

Acer saccharinum.

ii. Pores (cross) visible to the naked eye with close scrutiny; pith flecks (cross) usually rather large, sometimes abundant, more or less conspicuous,

Acer rubrum.

dd. Rays (cross) not uniform, some of them conspicuously broad.

e. Rings (cross) strongly sinuous; wood white, not showing marked graining on tangential- and radial-sections; broad rays (cross) confined to short radii of the concave portions of the rings.............. **Carpinus caroliniana.**

ee. Rings (cross) regular, not strongly sinuous; wood brownish to reddish, showing marked graining on tangential- and radial-sections; broad rays (cross) uniformly distributed, not confined to short radii.

f. Rays (cross) mostly all broad; *vessels (tangential) with spirals; rays (tangential) between broad rays rarely or never uniseriate;* wood cross-grained, difficult to split.................. **Platanus occidentalis.**

ff. Rays (cross) only part of them broad; *vessels (tangential) without spirals; rays (tangential) between broad rays mostly uniseriate;* wood mostly straight-grained, easy to split...... **Fagus grandifolia,** p. 227.

cc. Rays (cross) mostly not plainly visible to the naked eye at a distance of 6-9 inches, indistinct to microscopic.

d. Pores (cross), or some of them, plainly visible to the naked eye at a distance of a foot, mostly conspicuous in the spring wood, for this reason often approaching characteristics of ring-porous group; *squarish crystals in cells of wood parenchyma (longitudinal) common.*

e. Heartwood chocolate-brown, heavy and hard, with mild odor, especially when wet; *rays (tangential) mostly 2-3-seriate, thick-tapering*.................. **Juglans nigra.**

ee. Heartwood light chestnut-brown, light and soft, odorless, even when wet; *rays (tangential) mostly uniseriate, slender-tapering*...................... **Juglans cinerea.**

dd. Pores (cross) not visible to the naked eye at a distance of a foot, not conspicuous in the spring wood; *squarish crystals in cells of wood parenchyma (longitudinal) uncommon or wanting.*

e. *Vessels (tangential) with spirals.*

f. Heartwood pale yellow to whitish; *rays (tangential) all alike, uniseriate throughout, or nearly so,*
Aesculus hippocastanum.

ff. Heartwood brownish, reddish or dark red-brown; *rays (tangential) not all alike, 1-6-seriate.*

g. Pores (cross) abundant or fairly abundant, rather evenly distributed; growth rings (cross) not sinuous; pith flecks (cross) usually present; wood parenchyma (cross) not forming distinct, tangential markings.

h. Growth rings narrow; cross-section with curious, sinuous-mottled appearance; sapwood whitish,
Pyrus americana.

hh. Growth rings rather wide; cross-section without sinuous-mottled appearance; sapwood light brown,
Amelanchier canadensis.

gg. Pores (cross) not abundant, solitary-scattering or in remote, radial lines; growth rings (cross) sinuous; pith flecks (cross) usually absent; wood parenchyma (cross) forming distinct, tangential markings. **Ostrya virginiana.**

ee. Vessels[a] *(tangential) without spirals.*

f. Rays (tangential) all alike, *uniseriate throughout or nearly so;* wood for the most part soft and light.

g. Pores (cross) of summer wood markedly smaller and fewer in number than pores of spring wood, arranged in more or less prominent, wavy, concentric lines; wood (radial) without silky luster; *rays (radial) with both upright and procumbent cells,* **Salix nigra.**

gg. Pores (cross) of summer wood not markedly smaller and fewer in number than pores of spring wood, not arranged in more or less prominent, wavy concentric lines; wood (radial) with silky luster; *rays (radial) with only procumbent cells* ....**Populus,** p. 229.

ff. Rays (tangential) not all alike, but some broad, *1-6-seriate;* wood mostly hard and heavy.

g. Growth rings (cross) indistinct, very narrow and crowded together; *tyloses (longitudinal) present; larger rays (tangential) 1-2-, occasionally 3-seriate,* **Nyssa sylvatica.**

gg. Growth rings (cross) distinct, not very narrow and not crowded together; *tyloses (longitudinal) absent; larger rays (tangential) 3-6-seriate.*

h. Rays (cross) just visible to the naked eye with close scrutiny; pores (cross) more or less uniformly distributed, neither larger nor more numerous in the spring wood; pith flecks (cross) rare or wanting; wood heavy and hard.

i. Larger rays (tangential) 3-5-seriate; pores (cross) visible to the naked eye with close scrutiny ....**Betula lenta.**

ii. Larger rays (tangential) 1-2-, sometmes 3-seriate; pores (cross) hardly visible to the naked eye with close scrutiny....**Betula lutea,** p. 227.

hh. Rays (cross) not visible to the naked eye with close scrutiny; pores (cross) not uniformly distributed, but somewhat larger and more numerous in the spring wood; pith flecks (cross) usually rather abundant; wood light and soft.

i. Pores (cross) of spring wood visible to the naked eye with close scrutiny; growth rings (cross) not marked by narrow, whitish, concentric lines; pith flecks (cross) usually small, not conspicuous, **Betula alba papyrifera.**

ii. Pores (cross) of spring wood not visible to the naked eye with close scrutiny; growth rings (cross) marked by narrow, whitish, concentric lines, especially near the periphery; pith flecks (cross) usually large, conspicuous, **Betula populifolia.**

aa. Pores (cross) not visible nor conspicuous, even with magnifier, *i. e., wood composed mostly of one kind of cells (tracheids), which are uniform in structure and arranged in definite radial rows;* resin ducts and resin cells (cross) often present, especially in the summer wood; rays (cross) never conspicuous.

b. Resin ducts or resin cells or both (cross) present, the former usually visible to the naked eye, the latter for the most part prominent and more or less confluent, forming conspicuous tangential lines; fusiform rays (tangential) present (absent in *Juniperus* and *Taxodium*).

c. Resin ducts and resin cells (cross) scattered, single or in groups, but never forming tangential lines; *fusiform rays (tangential) present; rays (radial) with tracheids.*

d. Heartwood distinct in color from sapwood; resin ducts (cross) conspicuous, because of size or color, *the epithelium cells thin-walled; fusiform rays (tangential) broad and prominent, usually with one to several large resin ducts.*

e. Resin ducts (cross) few, widely scattering, *without tyloses;* resin cells (cross) present near the outer limit of the summer wood; *tracheids (radial) with occasional spirals;* heartwood light russet-brown, **Larix laricina,** p. 219.

ee. Resin ducts (cross) numerous, evenly scattered through the rings, *with prominent tyloses;* resin cells (cross) wholly absent; *tracheids (radial) wholly without spirals;* heartwood whitish, orange to reddish.

f. Transition (cross) from spring wood to summer wood gradual, the growth rings distinguished by narrow lines of darker colored summer wood; wood soft and light, slightly resinous; *lateral walls of ray cells (radial) of spring wood with 1-2 large pits to each tracheid.*

g. Walls of ray tracheids (radial) smooth; pits (radial) on the tangential walls of the summer-wood cells numerous.................. **Pinus strobus,** p. 215.

gg. Walls of ray tracheids (radial) conspicuously toothed; pits (radial) on the tangential walls of the summer-wood cells absent, **Pinus resinosa,** p. 217.

ff. Transition (cross) from spring wood to summer wood more or less abrupt, the growth rings distinguished by broad bands of darker colored summer wood; wood medium hard and heavy, strongly resinous; *lateral walls of ray cells (radial) of spring wood with 2-6 small pits to each tracheid.*

g. Growth rings (cross) wide, the resin ducts small, widely scattering; *fusiform rays (tangential) having the cells of the inflated portion all or mostly thick-walled, not broken out*............**Pinus banksiana.**

gg. Growth rings (cross) narrow, the resin ducts large, chiefly in the summer wood; *fusiform rays (tangential) having the cells of the inflated portion all or mostly thin-walled, all broken out,* **Pinus rigida.**

dd. Heartwood not distinct in color from the sapwood; resin ducts (cross) not conspicuous, of same color as surrounding wood; *fusiform rays (tangential) narrow, not prominent, with only one small resin duct.*

e. Growth rings (cross) wide; resin ducts (cross) rather numerous, *the epithelium cells thin-walled.*

f. Resin ducts (cross) scattered through both spring and summer wood, *with tyloses usually absent; pits (radial) on the tangential walls of the summer wood chiefly confined to the outermost tracheid wall,*

Picea canadensis.

ff. Resin ducts (cross) confined chiefly to the summer wood, *with tyloses present; pits (radial) on the tangential walls of the summer wood not confined to the outermost wall, but usually numerous,* **Picea mariana.**

ee. Growth rings (cross) narrow; resin ducts (cross) not numerous, *the epithelium cells thick-walled,* **Picea rubra,** p. 217.

cc. Resin ducts and resin cells (cross) not scattered, but more or less confluent and forming tangential lines; *fusiform rays (tangential) absent; rays (radial) chiefly or wholly without tracheids.*

d. Wood with odor like cedar oil, especially when wet; heartwood purplish to red-brown, with yellow-white sapwood, its smoothed surface dull; rings (cross) wavy and sinuous, **Juniperus virginiana.**

dd. Wood odorless, even when wet; heartwood dull yellow- or gray-brown, differing only in shade from the sapwood, its smoothed surface greasy or waxy; rings (cross) regular, not wavy nor sinuous...... **Taxodium distichum,** p. 223.

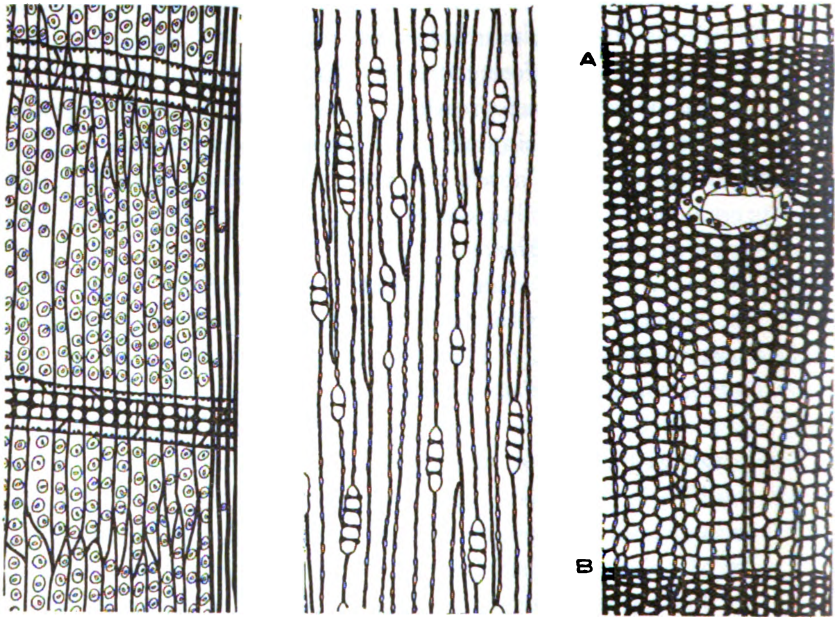
bb. Resin ducts (cross) absent and resin cells (cross), if present not prominent, not forming conspicuous, tangential lines; *fusiform rays (tangential) absent.*

c. Wood with mild odor like cedar oil, especially when wet; heartwood distinct in shade from the sapwood; rings (cross) wavy; wood spongy, difficult to cut smoothly across the grain; *ray tracheids (radial) wholly absent,* **Thuja occidentalis,** p. 221.

cc. Wood without odor of cedar oil, even when wet; heartwood not distinct in shade from the sapwood; rings (cross) not wavy; wood not spongy, easy to cut smoothly across the grain; *ray tracheids (radial) present.*

d. Transition (cross) from spring wood to summer wood abrupt; wood light red-brown, with rancid odor, especially when wet, cross-grained, splintery and hard to work; resin cells (cross) prominent, but not numerous; *ray tracheids (radial) prominent*............ **Tsuga canadensis,** p. 219.

dd. Transition (cross) from spring wood to summer wood gradual; wood yellow-white to pale brown, odorless, even when wet, straight-grained, not splintery and easy to work; resin cells (cross) absent; *ray tracheids (radial) not prominent, occasional*.................. **Abies balsamea,** p. 221.



RADIAL. **TANGENTIAL.** **CROSS.**

Sections of wood of Pinus resinosa, x 101.

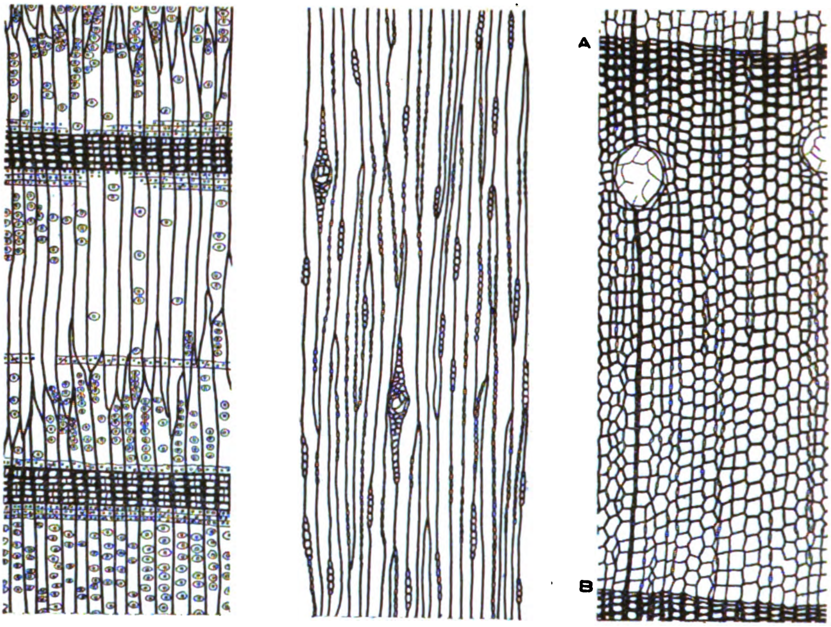
Red Pine. Norway Pine

Pinus resinosa Ait.

CHARACTERISTICS.—Bark thick, red-brown, shallowly fissured into broad, flat ridges; sapwood thin, yellow to white; heartwood pale red; non-porous; growth rings very wide and distinct; transition from spring wood to summer wood very gradual; rays numerous, faintly distinct, with fusiform rays few and these chiefly rather low and broad; resin ducts numerous, evenly scattered through the rings, with prominent tyloses; resin cells absent; tracheids without spirals.

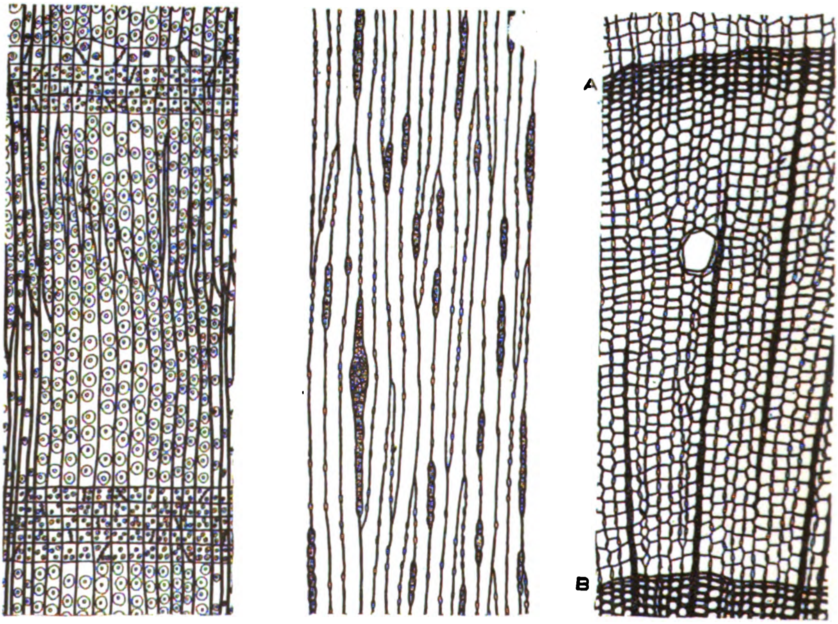
QUALITIES.—Rather light in weight, 31 pounds per cubic foot, seasoned; fairly soft; moderately strong; shrinkage 3 percent; warps moderately; not durable when exposed; straight- and very close-grained; easily worked; splits readily, but nails well.

USES.—Piles, flooring, sheathing, freight cars, poles, masts, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Pinus strobus, x 40.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Picea rubra, x 97.

White Pine

Pinus strobus L.

CHARACTERISTICS.—Bark thick, dark gray, shallowly fissured into broad, scaly ridges; sapwood thin, whitish; heartwood clear yellow to light brown, turning red on exposure to the atmosphere; non-porous; growth rings wide, distinct; transition from spring wood to summer wood gradual; rays very faint, without resin ducts, the fusiform rays few; resin ducts (vertical) numerous, evenly scattered through the rings, with prominent tyloses; resin cells wholly absent; tracheids entirely without spirals.

QUALITIES.—Very light in weight, 27 pounds per cubic foot, seasoned; very soft; rather weak; shrinkage 3 percent; warps very little; moderately durable when exposed; very close- and straight-grained; easily worked; splits readily, but nails well.

USES.—Doors, window-sashes, interior finish and other carpentry, patterns, cabinet-work, matches, boxes, etc.; the most generally useful of all American woods.

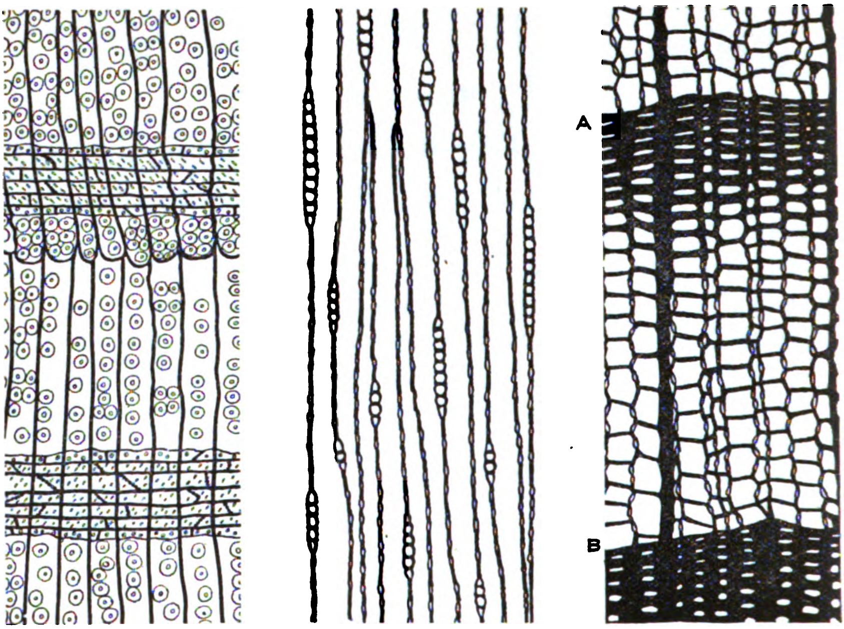
Red Spruce

Picea rubra (DuRoi) Dietr.

CHARACTERISTICS.—Bark red-brown, with thin, irregular scales; heartwood dull white, with occasional reddish streaks, with sapwood of nearly the same shade; non-porous; growth rings narrow, but distinct; transition from spring wood to summer wood gradual; rays very faint, the fusiform ones narrow; resin ducts few and small, scattered, without tyloses; resin cells absent; tracheids without spirals.

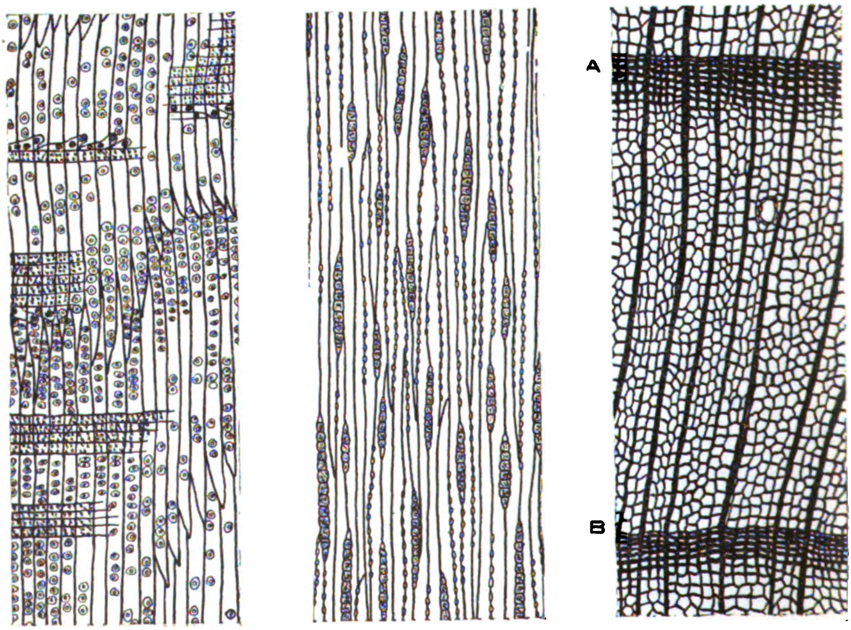
QUALITIES.—Rather light in weight, 28 pounds per cubic foot, seasoned; soft; fairly strong; shrinkage 3 percent; warps little; fairly durable when exposed; straight-grained; easy to plane and tolerably easy to saw, but hard to chisel neatly; splits easily in nailing.

USES.—Boats and canoes, oars and paddles, ship timbers, building construction, silos, sounding boards, paper pulp, ladders, etc.



RADIAL. **TANGENTIAL.** **CROSS.**

Sections of wood of Tsuga canadensis, x 90.



RADIAL. **TANGENTIAL.** **CROSS.**

Sections of wood of Larix laricina, x 65.

Hemlock

Tsuga canadensis (L.) Carr.

CHARACTERISTICS.—Bark thick, red-brown or grayish, deeply divided into narrow, rounded, scaly ridges; heartwood light red-brown, ill-smelling, with thin, darker colored sapwood; non-porous; growth rings rather wide, distinct; transition from spring wood to summer wood abrupt; rays numerous, obscure, none of them fusiform; resin ducts absent; resin cells few in number, but prominent; tracheids without spirals.

QUALITIES.—Rather light in weight, 26 pounds per cubic foot, seasoned; soft; fairly strong; shrinkage 3 percent; warps little; checks badly; not durable when exposed; coarse- and crooked-grained; difficult to work, because brittle and splintery; splits easily, but holds nails well.

USES.—Dimension materials, timbers, joints, rafters, plank walks, laths, etc.

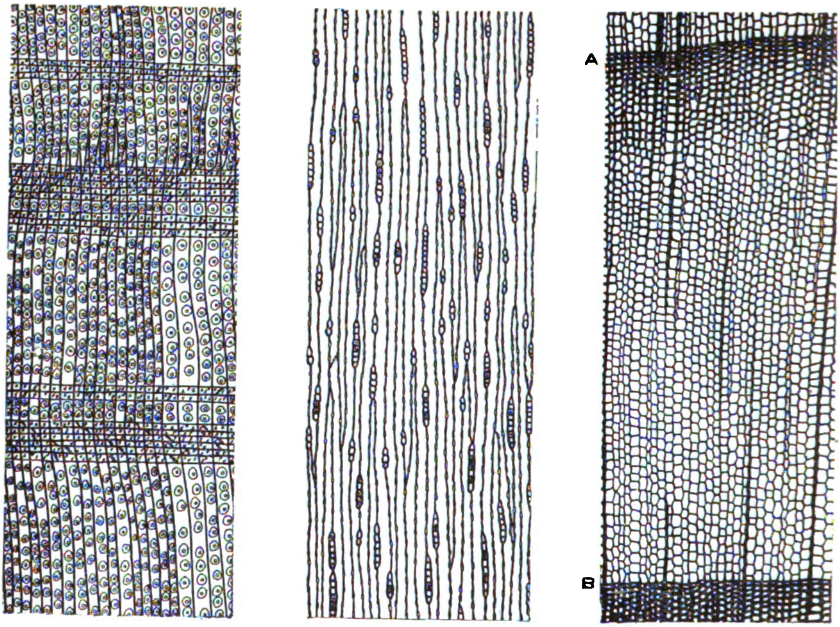
Tamarack

Larix laricina (DuRoi) Koch

CHARACTERISTICS.—Bark red-brown, scaly, without ridges; sapwood thin, nearly white; heartwood russet-brown; non-porous; growth rings rather broad and uniform, distinct; transition from spring wood to summer wood more or less abrupt; rays inconspicuous, many of them broadly fusiform, prominent and containing resin ducts; resin ducts (vertical) few, widely scattered, without tyloses; resin cells present near outer limit of summer wood; tracheids mostly without spirals.

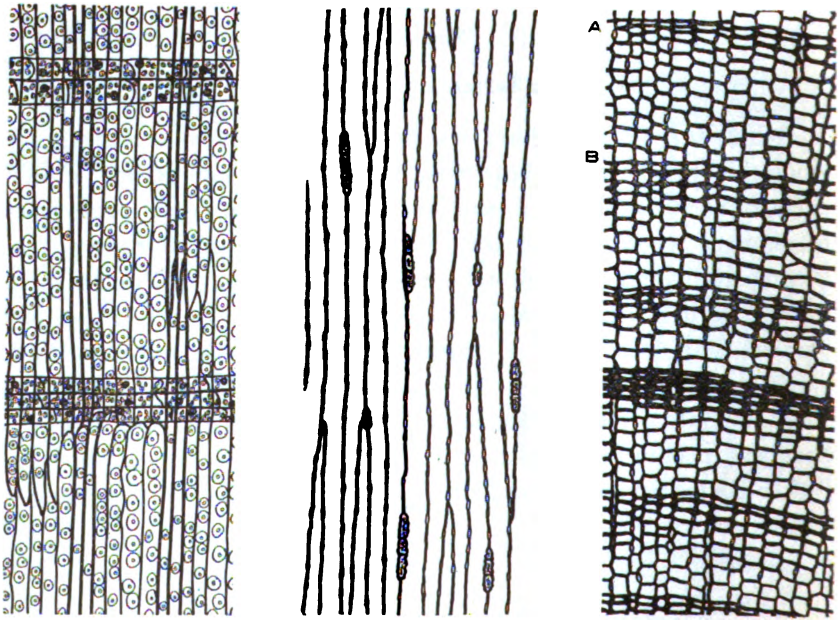
QUALITIES.—Weight medium, 39 pounds per cubic foot, seasoned; hardness medium; rather strong; shrinkage 3 percent; warps but little; rather coarse-grained; very durable in contact with the soil; easy to work; splits readily.

USES.—Ship and boat timbers, telegraph poles, fence posts, railroad ties, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Abies balsamea, x 44.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Thuja occidentalis, x 139.

Balsam Fir

Abies balsamea (L.) Mill.

CHARACTERISTICS.—Bark pale gray-brown and marked by swollen resin chambers, or red-brown and roughened by small, scaly plates; sapwood thick, whitish; heartwood yellow-white to pale brown; non-porous; growth rings wide, indistinct; transition from spring wood to summer wood very gradual; rays inconspicuous, never fusiform and mostly without resin ducts; both resin ducts (vertical) and resin cells absent; tracheids without spirals.

QUALITIES.—Very light in weight, 23 pounds per cubic foot, seasoned; very soft; weak; shrinkage moderate; warps little; coarse-grained; perishable in contact with the soil; works easily; splits readily.

USES.—Cut, sold and used with spruce and pine, boxes, crates, packing cases, sheathing, etc.

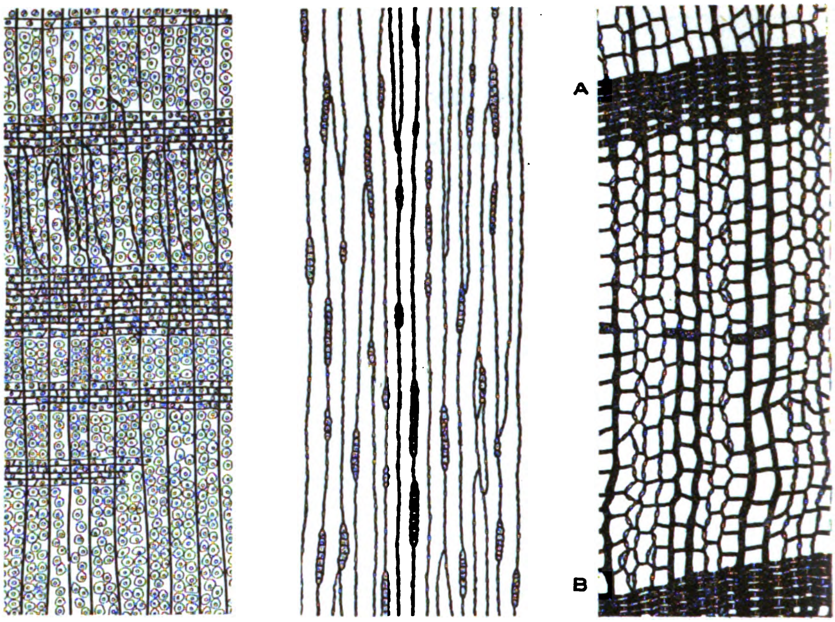
Arbor Vitae. White Cedar

Thuja occidentalis L.

CHARACTERISTICS.—Bark thin, light red-brown, slightly furrowed or deciduous in ragged strips; sapwood thin, whitish; heartwood pale yellow-brown; wood with mild odor like cedar oil; non-porous; growth rings narrow to wide, rather irregular and wavy, fairly distinct by the narrow, but denser summer wood; transition from spring wood to summer wood more or less abrupt; rays very faint, microscopic; resin ducts absent and resin cells few and usually widely scattering; tracheids wholly without spirals.

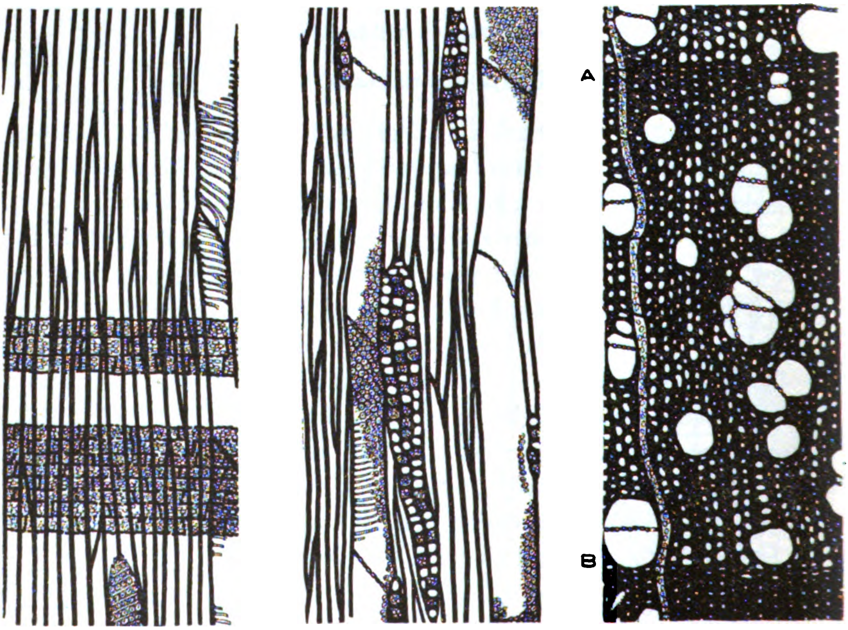
QUALITIES.—Very light in weight, 19 pounds per cubic foot, seasoned; very soft; very weak; shrinks and checks but little; warps little; rather coarse-grained; brittle; very durable in contact with the soil; easily worked; splits easily, but nails well.

USES.—Posts, railroad ties, shingles, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Taxodium distichum, x 47.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Acer saccharum, x 127.

Bald Cypress. Cypress[1]

Taxodium distichum (L.) Richard

CHARACTERISTICS.—Bark light red, shallowly fissured into broad, flat plates and peeling into fibrous strips; sapwood thin, nearly white; heartwood dull yellow- or gray-brown or sometimes blackish; non-porous; growth rings usually very broad and well-marked by the dense and conspicuous summer wood; transition from spring wood to summer wood somewhat gradual; rays very obscure, none of them fusiform; resin ducts absent; resin cells numerous, large, more or less confluent and forming tangential lines on the cross-section; tracheids wholly without spirals.

QUALITIES.—Fairly light in weight, 29 pounds per cubic foot, seasoned; soft; rather weak; shrinkage 3 percent; warps but little, although liable to check; close-grained; very durable in contact with the soil; easy to work; nails well; frequently "peggy" or "pecky" from a fungous disease.

USES.—Shingles, posts, interior finish, boats, cooperage, greenhouse construction, etc.

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[1] Not native to Vermont, but included here because of its widespread use.

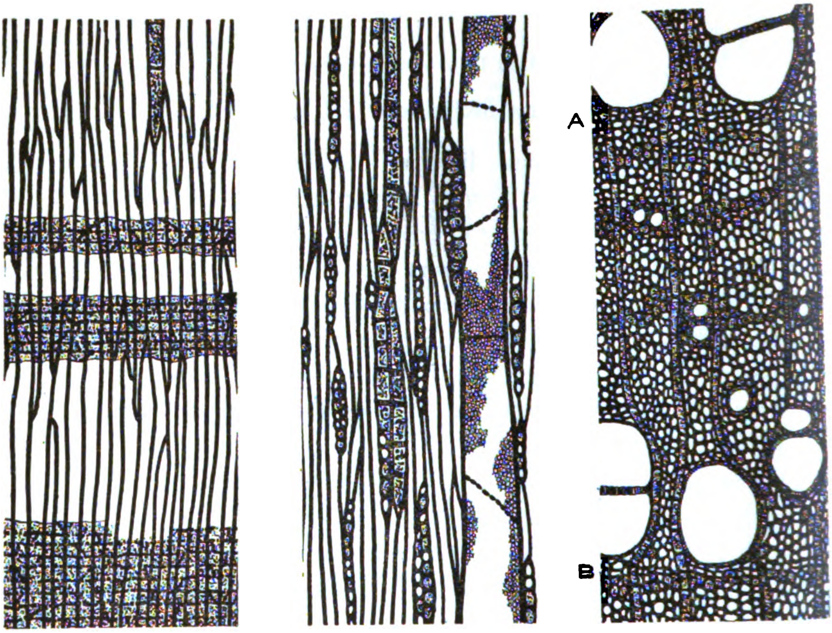
Sugar Maple. Rock Maple

Acer saccharum Marsh.

CHARACTERISTICS.—Bark dark gray and deeply furrowed, often cleaving up at one edge in long, thick plates; sapwood thin, lighter colored than the light brown heartwood; diffuse-porous; growth rings narrow, but distinct; pores somewhat uniform in size, not crowded, inconspicuous; rays fine, but distinct; vessels with spirals.

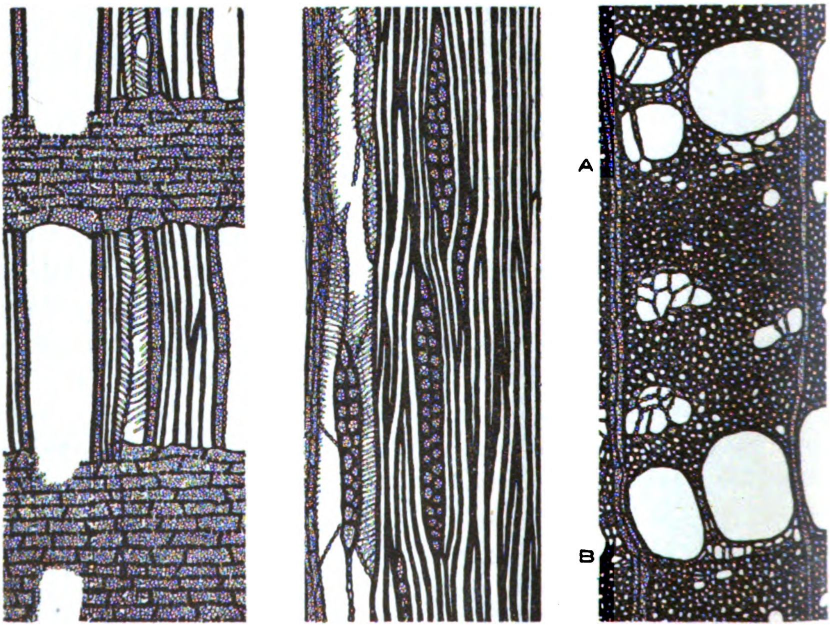
QUALITIES.—Heavy, 43 pounds per cubic foot, seasoned; very hard; very strong; shrinkage 5 percent; warps badly; close-grained, but the fibers sometimes twisted, waved or curly, producing "bird's eye" and "curly" effects; not durable when exposed; wears evenly; splits badly in nailing; hard to work.

USES.—Flooring, fuel, furniture, wagon-stock, carving, tool-handles, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Fraxinus americana, x 92.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Ulmus americana, x 138.

White Ash

Fraxinus americana L.

CHARACTERISTICS.—Bark gray, deeply furrowed into firm, narrow, flattened ridges; sapwood thick, whitish; heartwood brownish; ring-porous; growth rings rather narrow, distinctly marked by 3-5 rows of large pores in the spring wood; pores of the summer wood small and inconspicuous, joined by wood parenchyma to form short, broken, tangential lines, especially near the periphery of the growth ring; rays inconspicuous to microscopic; vessels without spirals.

QUALITIES.—Fairly heavy, 39 pounds per cubic foot, seasoned; rather hard; fairly strong; shrinkage 5 percent; warps little; straight- and close-grained; not durable in contact with the soil; splits readily and nails badly; becomes brittle with age.

USES.—Farm implements, oars, handles, interior finish, cheap cabinet-work, carriage-stock, etc.

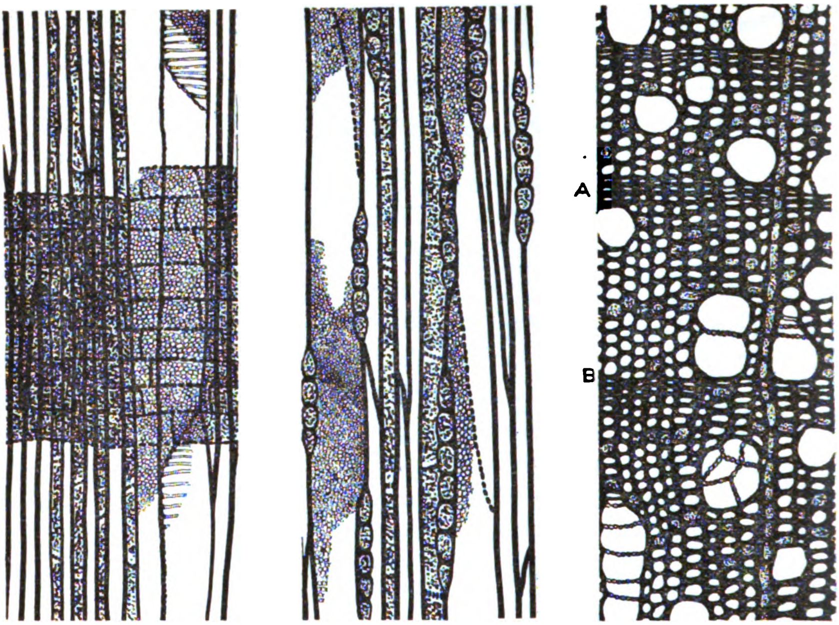
American Elm. White Elm

Ulmus americana L.

CHARACTERISTICS.—Bark ash-gray, deeply fissured into broad, scaly ridges; sapwood thick, yellowish; heartwood light brown; ring-porous; growth rings rather wide, distinctly marked by usually one row of large pores in the spring wood; pores of summer wood somewhat smaller, forming broad, mostly connected, tangential lines, which are strongly wavy; rays numerous, inconspicuous; vessels with spirals.

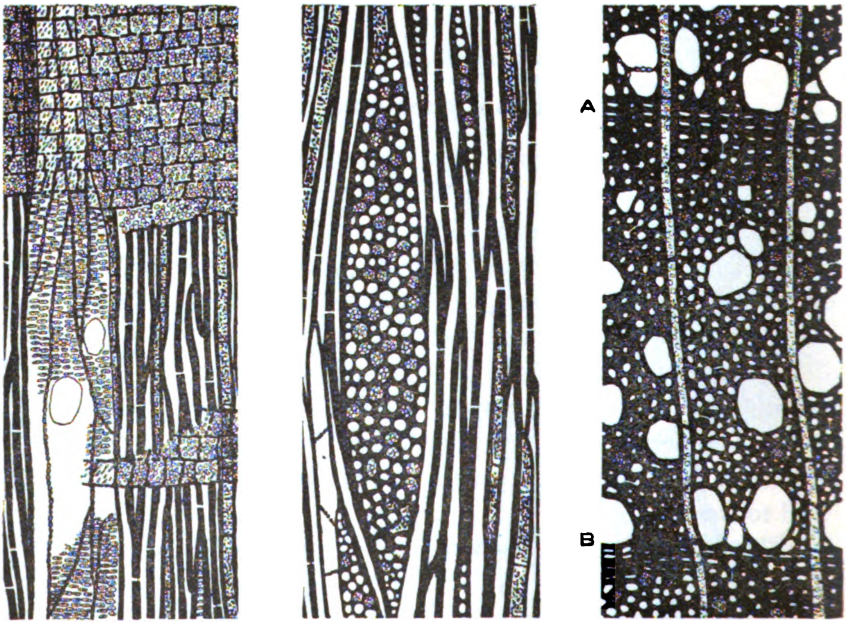
QUALITIES.—Fairly heavy, 34 pounds per cubic foot, seasoned; hardness medium; fairly strong; shrinkage 5 percent; warps and checks considerably; coarse-grained, with the fibers commonly interlaced; not durable in contact with the soil; difficult to split; tough and hard to work.

USES.—Wheel-stock, cooperage, heavy timbers, heavy agricultural implements, etc.



RADIAL. **TANGENTIAL.** **CROSS.**

Sections of wood of Betula lutea, x 163.



RADIAL. **TANGENTIAL.** **CROSS.**

Sections of wood of Fagus grandifolia, x 156.

Yellow Birch. Gray Birch

Betula lutea Michx. f.

CHARACTERISTICS.—Bark silvery yellow-gray and breaking into strips more or less curled at the edges or blackish and deeply and irregularly fissured into large, thin plates; sapwood thin, whitish; heartwood light brown tinged with red; diffuse-porous; growth rings fairly distinct; pores more or less uniform in size, not crowded, inconspicuous; rays numerous, indistinct; vessels without spirals.

QUALITIES.—Heavy, 40 pounds per cubic foot, seasoned; moderately hard; very strong; shrinkage 6 percent; warps little; close-grained and compact; not durable when exposed; difficult to split and holds nails well; rather hard to work, but polishes well.

USES.—Furniture, spools, flooring, shoe lasts and pegs, handles, etc.

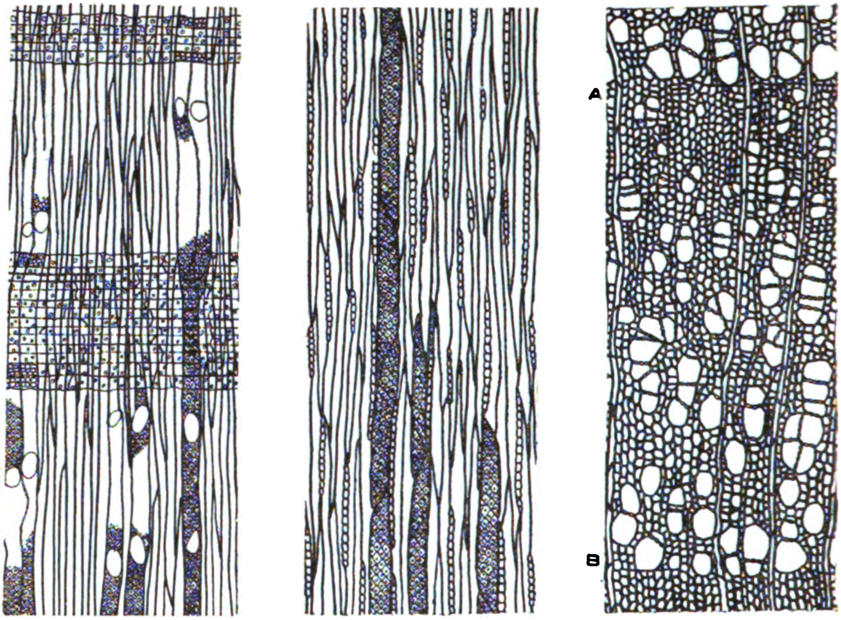
Beech

Fagus grandifolia Ehrh.

CHARACTERISTICS.—Bark close, smooth, steel-gray, often mottled by darker blotches and bands; sapwood thin, whitish; heartwood light or dark red; diffuse-porous; growth rings obscure; pores largest in spring wood, gradually diminishing in size toward outer limit of summer wood; rays of two kinds, partly very broad and partly very narrow; vessels without spirals.

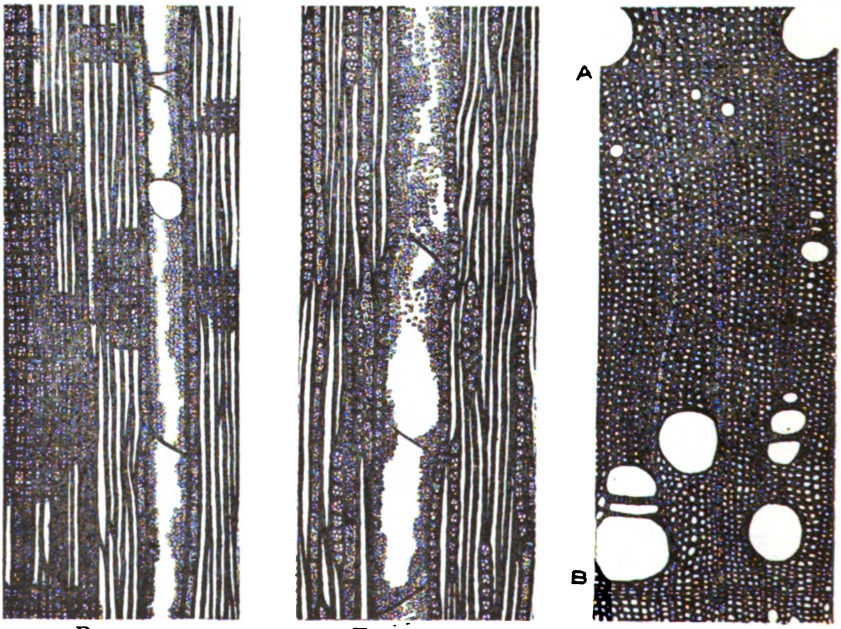
QUALITIES.—Heavy, 42 pounds per cubic foot, seasoned; rather hard; strong; shrinkage 5 percent; warps and checks during seasoning; straight- and very close-grained; not durable when exposed; moderately difficult to split; tough; hard to work; difficult to nail.

USES.—Ship timbers, flooring, tool-handles, furniture, fuel, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Populus tremuloides, x 80.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Carya ovata, x 100.

American Aspen. Trembling Poplar. Popple

Populus tremuloides Michx.

CHARACTERISTICS.—Bark thin, yellowish or greenish and smooth, often roughened with darker, horizontal bands or wart-like excrescences; sapwood thin, whitish; heartwood light brown; diffuse-porous; growth rings very wide, not well-defined; pores more or less uniform in size, but rather more crowded in the spring wood; rays very fine and indistinct; vessels without spirals.

QUALITIES.—Very light, 25 pounds per cubic foot, seasoned; soft; weak; shrinks moderately; warps considerably to excessively, but checks little; close-grained; not durable when exposed; works easily.

USES.—Paper pulp, boxes, crates, excelsior, woodenware, etc.

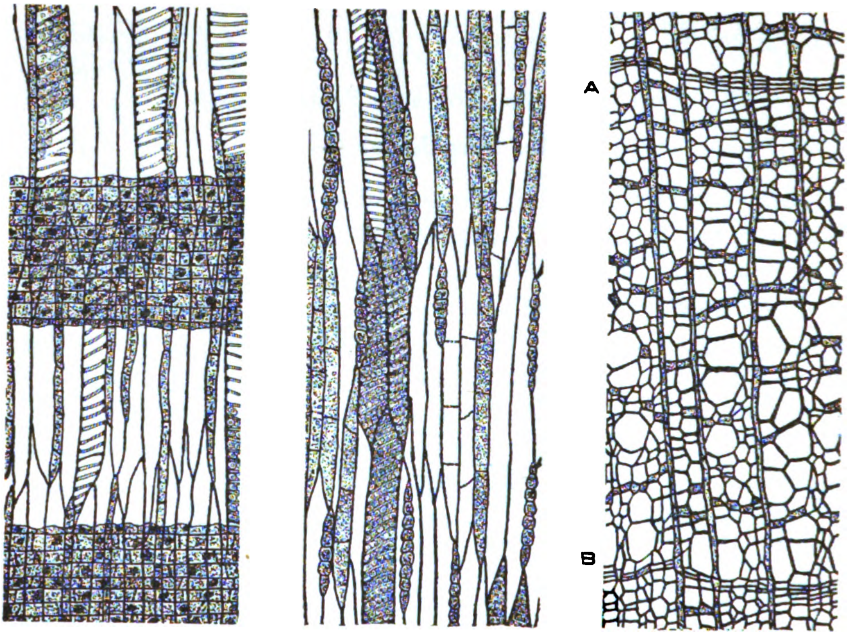
Shellbark Hickory

Carya ovata (Mill.) K. Koch

CHARACTERISTICS.—Bark thick and grayish, separating into thick strips 1-3 feet long, free at one or both ends, giving the log a shaggy appearance; sapwood thin, whitish; heartwood light brown; ring-porous; growth rings narrow, but distinctly marked by the one or more rows of relatively large pores in the spring wood; pores of the summer wood small and inconspicuous; rays numerous, but inconspicuous to microscopic; wood parenchyma forming more or less continuous, tangential lines as distinct, or nearly so, as the rays; vessels without spirals, but containing tyloses.

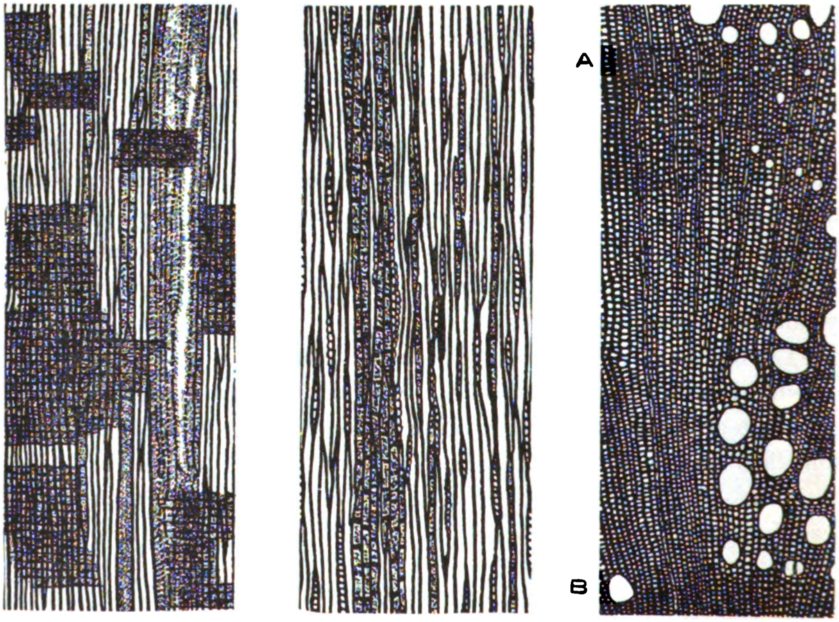
QUALITIES.—Very heavy, 51 pounds per cubic foot, seasoned; very hard; very strong; shrinkage 10 percent; warps badly; straight- and close-grained; not durable when exposed; hard to split and very difficult to nail; very tough and hard to work.

USES.—Agricultural implements, handles, carriage-stock, sled runners, fuel, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Tilia americana, x 112.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Quercus rubra, x 64.

Basswood

Tilia americana L.

CHARACTERISTICS.—Bark thick, dark gray or brownish, deeply furrowed into broad, scaly ridges; inner bark fibrous and tough; sapwood thick, light red-brown, hardly distinguishable from the heartwood; diffuse-porous; growth rings rather narrow, but distinct; pores all the same sizes or nearly so, rather evenly distributed; rays numerous, obscure; wood-parenchyma cells forming continuous or somewhat broken, tangential lines or bands, alternating with wood elements in a tier-like arrangement; vessels with spirals.

QUALITIES.—Light in weight, 28 pounds per cubic foot, seasoned; very soft; very weak; shrinkage 6 percent; very straight- and close-grained; warps comparatively little; not durable in contact with the soil; somewhat tough to split and nails well; very easily worked.

USES.—Carriage and wagon bodies; woodenware, boxes, toys, numerous small articles, etc.

Red Oak

Quercus rubra L.

CHARACTERISTICS.—Bark gray-brown, smooth or shallowly fissured into thin, firm, broad ridges; inner bark light red; sapwood thin, darker than the light red-brown heartwood; ring-porous; growth rings rather wide, distinctly marked by several rows of very large pores in the spring wood; pores of summer wood arranged in radial, branching lines, diminishing in size toward outer limits of the summer wood; wood parenchyma grouped irregularly around the pores; rays few, but mostly broad and conspicuous; vessels without spirals.

QUALITIES.—Rather heavy, 45 pounds per cubic foot, seasoned; fairly hard; rather strong; shrinkage 6-10 percent; warps and checks badly; coarse-grained; moderately durable in contact with the soil; splits readily and nails badly.

USES.—Furniture, interior finish, cooperage, agricultural implements, fuel, etc.

A LIST OF VERMONT WOODS ARRANGED IN THE ORDER OF THEIR WEIGHT FROM HEAVY TO LIGHT

1. Carya ovata
2. Carya alba
3. Carya glabra
4. Betula lenta
5. Quercus alba
6. Quercus macrocarpa
7. Carpinus caroliniana
8. Ulmus racemosa
9. Quercus velutina
10. Acer saccharum
11. Fagus grandifolia
12. Betula lutea
13. Fraxinus americana
14. Quercus rubra
15. Ulmus americana
16. Fraxinus nigra
17. Fraxinus pennsylvanica
18. Larix laricina
19. Acer rubrum
20. Betula alba papyrifera
21. Prunus serotina
22. Platanus occidentalis
23. Acer saccharinum
24. Juniperus virginiana
25. Pinus resinosa
26. Picea mariana, Picea rubra
27. [1]Taxodium distichum
28. Tilia americana
29. Salix nigra
30. Tsuga canadensis
31. Liriodendron tulipifera
32. Juglans cinerea
33. Picea canadensis
34. Pinus strobus
35. Populus tremuloides
36. Abies balsamea
37. Thuja occidentalis

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[1] Not native to Vermont.

GLOSSARY

WITH PAGE REFERENCES TO EXPLANATORY FIGURES

Abortive. Defective or barren.
Achene. A small, dry, one-seeded fruit in which the ovary wall adheres to the seed.
Acorn. The fruit of the oak.
Acuminate. Gradually tapering to the apex. Page 7.
Acute. Terminating with a sharp angle. Page 7.
Alternate. Said of leaves, branches, buds, etc., scattered singly along the stem; not opposite.
Androgynous. Composed of both staminate and pistillate flowers.
Anterior. The front side of a flower, remote from the axis of inflorescence.
Anther. The part of a stamen which bears the pollen. Page 8.
Apetalous. Without petals.
Apex. The top, as the tip of a bud or the end of a leaf which is opposite the petiole.
Apiculate. Ending in a short-pointed tip.
Appressed. Lying close and flat against.
Arborescent. Attaining the size or character of a tree.
Aromatic. Fragrant; with an agreeable odor.
Axil. The upper one of the two angles formed by the juncture of a leaf with a stem.
Axillary. Situated in an axil.

Bark. The outer covering of a trunk or branch. Page 195.
Bearded. Bearing a long, bristle-like appendage, or furnished with long or stiff hairs.
Berry. A fruit which is fleshy throughout.
Bipinnate. Twice pinnate.
Blade. The expanded portion of a leaf, etc.
Bloom. A powdery or waxy substance easily rubbed off.
Bract. A more or less modified leaf subtending a flower or belonging to an inflorescence.
Branch. A secondary division of a trunk.
Branchlet. A small branch.
Bud. An undeveloped stem or branch, with or without scales.
Bud-scales. Modified leaves covering a bud.
Bundle-scars. Dots on the surface of a leaf-scar, which are scars left by the fibro-vascular bundles which run through the petiole into the blade of the leaf. Page 10.
Bur. A spiny fruit.

Calyx. The outer part of a perianth, usually green in color. Page 8.
Cambium. The ring or zone of tender, growing cells between the bark and the wood.
Campanulate. Bell-shaped.
Capsule. A dry fruit of more than one carpel which splits at maturity to release the seeds.
Carpel. A simple pistil, or one member of a compound pistil.
Catkin. A spike of unisexual flowers, each subtended by a bract, and usually deciduous in one piece.
Cell. One of the minute units or elements, of very various forms, of which plants are formed. Page 195.
Cellulose. The fundamental substance of the cell-wall.
Chambered. Said of pith which is interrupted by hollow spaces.
Ciliate. Fringed with hairs on the margin.
Cinereous. Ash-gray color.
Claw. The narrow, stalk-like base of a petal, sepal, etc.
Cleft. Cut about half-way to the middle.
Cluster. A group of two or more organs (flowers, fruit, etc.) on a plant at a node or end of a stem.
Columnar. Having the form of a column.
Compound. Composed of two or more similar parts united into a whole.
Compound leaf, one divided into separate leaflets.
Compressed. Flattened laterally.

Concentric. One within another, with a common center.
Cone. A fruit with woody, overlapping scales.
Confluent. Blended or flowing into one; passing by degrees one into the other.
Conical. Cone-shaped, largest at the base and tapering to the apex.
Conifer. A tree of the pine family, so called from its bearing cones.
Coniferous. Cone-bearing; of, or pertaining to, the pine family.
Connective. The portion of a stamen which connects the two cells of the anther.
Cordate. Heart-shaped. Page 7.
Coriaceous. Leather-like in texture.
Corky. Made of, or like cork.
Corolla. The inner part of a perianth, usually bright colored. Page 8.
Corrugated. Wrinkled or in folds.
Corymb. A flower-cluster in which the axis is shortened and the pedicels of the lower flowers lengthened, forming a flat-topped inflorescence, the marginal flowers blooming first. Page 9.
Corymbose. Arranged in corymbs.
Crenate. Dentate, with the teeth much rounded. Page 8.
Crenulate. Finely crenate.
Cross-grained. Having the grain gnarled and hard to cut.
Cross-section. A section of a body at right angles to its length. Page 195, d.
Crown. The upper part of a tree, including the living branches with their foliage.
Cutting. A piece of stem, root or leaf which, if cut off and placed in contact with the soil, will form new roots and buds, reproducing the parent plant.
Cyme. A broad and flattish inflorescence, the central flowers of which bloom first. Page 9.
Cymose. Arranged in cymes.

Deciduous. Not persistent; falling away, as the leaves of a tree in autumn.
Decurrent. Said of a leaf which extends down the stem below the point of fastening.
Decussate. Alternating in pairs at right angles.
Dehiscent. Opening by valves or slits.
Deltoid. Delta-shaped; triangular.
Dentate. Toothed, with the teeth usually pointed and directed outward. Page 8.
Depressed. Somewhat flattened from above.
Dichotomous. Branching regularly in pairs.
Diffuse-porous. Said of wood whose pores are nearly uniform in size and more or less evenly diffused through both spring and summer wood.
Digitate. Said of a compound leaf in which the leaflets are borne at the apex of the petiole; finger-shaped.
Dioecious. Unisexual, with staminate and pistillate flowers on different individuals.
Distribution. The geographical extent and limits of a species.
Divergent. Said of buds, cones, etc., which point away from the twig, or of pine needles, etc., which spread apart.
Dormant. A term applied to parts which are not in active life.
Dorsal. Pertaining to the back or outer surface of an organ.
Downy. Covered with fine hairs.
Drupe. A fleshy or pulpy fruit in which the inner portion is hard or stony.
Duct. See resin duct.

Ellipsoid. An elliptical solid.
Elliptical. Oval or oblong with regularly rounded ends. Page 7.
Emarginate. Notched at the apex. Page 7.
Entire. Without divisions, lobes or teeth.
Epithelium. The somewhat modified parenchyma lining certain intercellular cavities, as the resin ducts.
Epithelium cell. A cell of the epithelium.
Escape. Any plant formerly cultivated that grows wild in fields.
Excrescences. Warty outgrowths or protuberances.
Exfoliate. To cleave off, as of the outer layers of bark.

Falcate. Scythe-shaped.
Fascicle. A compact cluster of leaves or flowers.
Fascicled. Arranged in fascicles.
Fastigiate. Said of branches which are erect and near together.
Feather-veined. Having veins extending from the midrib to the margin, feather-wise.
Fertile. Capable of bearing fruit.
Fertilization. The mingling of the contents of a male (pollen) and female (ovule) cell.
Fibro-vascular bundles. The strands that make up the framework of higher plants.
Filament. The part of a stamen which bears the anther. Page 8.
Filamentose or *Filamentous.* Composed of threads or filaments.
Flaky. With loose scales easily rubbed off (bark).
Fleshy. Succulent; juicy.
Flower. An axis bearing stamens or pistils or both (calyx and corolla usually accompany these). Page 8.
Fluted. With rounded ridges.
Fruit. The part of a plant which bears the seed.
Fungous. Relating to the *Fungi*, i. e., plant organisms of a lower order destitute of chlorophyll.
Fusiform. Thick, but tapering towards each end. *Fusiform ray*, a medullary ray which is fusiform in cross-section.

Germinate. To sprout, as of a seed.
Gibbous. Swollen on one side.
Glabrous. Neither rough, pubescent, nor hairy; smooth.
Gland. Secreting surface or structure; a protuberance having the appearance of such an organ.
Glandular. Bearing glands.
Glaucous. Covered or whitened with a bloom.
Globose. Spherical or nearly so.
Globular. Nearly globose.
Graining. The fibrous arrangement of the particles in wood, determining its hardness, splitting qualities, smoothness, etc.
Gregarious. Growing in groups or colonies.
Growth ring. An annual ring of growth. Page 195, VIII, h.

Habit. The general appearance of a plant, best seen from a distance.
Habitat. The place where a plant naturally grows, as in water, clay soil, marsh, etc.
Hairy. With long hairs.
Halberd-shaped. Like an arrow-head, but with the basal lobes pointing outward nearly at right angles. Page 7.
Heartwood. The dead central portion of the trunk or large branch of a tree. Page 195, VIII, c.
Hirsute. Covered with rather coarse or stiff hairs.
Hoary. Gray-white with a fine, close pubescence.
Homogeneous. Uniform; composed of similar parts or elements.
Hybrid. A cross between two nearly related species, formed by the action of the pollen of one upon the pistil of the other, yielding an intermediate form.
Hybridize. Forming a cross-breed of two species.

Imbricate. Overlapping, like the shingles on a roof.
Indehiscent. Not opening by valves or slits; remaining persistently closed.
Indigenous. Native and original to a region.
Inflorescence. The flowering part of a plant, and especially its arrangement.
Interlaced. Twisted or linked into each other.
Internode. The portion of a stem between two nodes.
Involucral. Pertaining to an involucre.
Involucre. A circle of bracts surrounding a flower or cluster of flowers.

Keeled. With a central ridge like the keel of a boat.
Key-fruit. An indehiscent winged fruit found in maples and ashes.

Laciniate. Cut into narrow, pointed lobes.
Lanceolate. Lance-shaped, broadest above the base and tapering to the apex, but several times longer than wide. Page 7.
Lateral. Situated on the side of a branch.
Leaf. The green expansions borne by the branches of a tree, consisting of a blade with or without a petiole.
Leaflet. One of the small blades of a compound leaf.
Leaf-scar. The scar left on a twig by the falling of a leaf. Page 10, c.
Legume. A pod-like fruit composed of a solitary carpel and usually splitting open by both sutures (*Leguminosae*).
Lenticels. Corky growths on young bark which admit air to the interior of a twig or branch.
Linear. Long and narrow, with parallel edges (as pine needles). Page 7.
Loam. A non-coherent mixture of sand, clay and organic matter.
Loamy. Of the nature of or like loam.
Lobe. Any division of an organ, especially if rounded.
Lobed. Provided with a lobe or lobes. Page 8.
Luster. Brilliancy or sheen; gloss.
Lustrous. Glossy; shining.

Medullary rays. Plates of cellular tissue radiating from the pith to the bark. They are primary when they extend from pith to bark and secondary when they are of less extent than the primary. Page 195, i.
Membranaceous. Thin and somewhat translucent.
Midrib. The central vein of a leaf or leaflet.
Monoecious. Unisexual, with staminate and pistillate flowers on the same individual.
Mucilaginous. Slimy; resembling or secreting mucilage or gum.
Mucronate. Tipped with a small, abrupt point. Page 7.

Naked. Lacking organs or parts which are normally present in related species or genera.
Naturalized. Said of introduced plants which are reproducing by self-sown seeds.
Nectariferous. Producing nectar.
Node. The place upon a stem which normally bears a leaf or whorl of leaves.
Non-porous. Said of wood whose structure is homogeneous, without large pores.
Nut. A hard and indehiscent, 1-celled, 1-seeded fruit.
Nutlet. A diminutive nut.

Oblanceolate. Lanceolate, with the broadest part toward the apex. Page 7.
Oblique. Slanting, or with unequal sides.
Oblong. Longer than broad, with sides approximately parallel. Page 7.
Obovate. Ovate, with the broadest part toward the apex. Page 7.
Obovoid. An ovate solid with the broadest part toward the apex.
Obtuse. Blunt or rounded at the apex. Page 7.
Opaque. Dull; neither shining nor translucent.
Opposite. Said of leaves, branches, buds, etc., on opposite sides of a stem at a node.
Orbicular. Circular. Page 7.
Oval. Broadly elliptical. Page 7.
Ovary. The part of a pistil that contains the ovules. Page 8.
Ovate. Egg-shaped, with the broad end basal. Page 7.
Ovoid. Solid ovate or solid oval.
Ovule. The part of a flower which after fertilization becomes the seed.

Palmate. Radiately lobed or divided; hand-shaped.
Panicle. A loose, irregularly compound inflorescence with pedicellate flowers. Page 9.
Paniculate. Arranged in panicles or resembling a panicle.
Papilionaceous. Butterfly-like, as in flowers of the *Leguminosae*.
Parenchyma. The soft, thin-walled, cellular tissue of plants. Page 195, IX, e.
Parenchyma elements. The cells or units composing the parenchyma.
Pedicel. The stalk of a single flower in a compound inflorescence.

Pedicellate. Borne on a pedicel.
Peduncle. A primary flower-stalk, supporting either a cluster or a solitary flower.
Pendent. Hanging downward.
Pendulous. More or less hanging or declined.
Perfect. Said of a flower with both stamens and pistil. Page 8.
Perianth. The calyx and corolla of a flower considered as a whole.
Periphery. Circumference.
Persistent. Long-continuous, as leaves through the winter, calyx on the fruit, etc.
Petal. One of the divisions of a corolla. Page 8.
Petiolate. Having a petiole.
Petiole. The stem or stalk of a leaf.
Petiolulate. Having a petiolule.
Petiolule. The stem or stalk of a leaflet.
Pilose. Hairy with long, soft hairs.
Pinnate. Compound, with the leaflets arranged along both sides of a common petiole.
Pistil. The seed-bearing organ of a flower, normally consisting of ovary, style and stigma. Page 8.
Pistillate. Provided with a pistil, but usually without stamens.
Pit. A small hollow or depression, as in a cell-wall. Page 195, IX, a.
Pith. The softer central part of a twig or stem. Page 195, VIII, g.
Pith flecks. Dark marks in timber due to the cavities made by the larvae of certain insects working in the cambium.
Pod. A dry and many-seeded, dehiscent fruit.
Pollen. The fecundating grains borne in the anther.
Polygamo-dioecious. Sometimes perfect, sometimes unisexual, both forms borne on different individuals.
Polygamo-monoecious. Sometimes perfect, sometimes unisexual, both forms borne on the same individual.
Polygamous. Sometimes perfect, sometimes unisexual, both forms borne on the same or on different individuals.
Pome. A fleshy fruit, as the apple.
Pore. Any small aperture; a name given to the large vessels or tracheids in hard woods.
Porous. Having large pores visible to the naked eye. See ring-porous and diffuse-porous.
Posterior. The back side of a flower, next to the axis of inflorescence.
Prickle. A small spine growing from the bark.
Procumbent. Lying flat, with the long axis in a horizontal direction.
Protoplasm. The living matter of cells, into which all nourishment is taken and from which all parts are formed.
Puberulent. Minutely pubescent.
Puberulous. Minutely pubescent.
Pubescence. A covering of short, soft hairs.
Pubescent. Covered with short, soft hairs.
Punctate. Dotted with translucent or colored dots or pits.

Raceme. A simple inflorescence of flowers on pedicels of equal length arranged on a common, elongated axis (rachis). Page 9.
Racemose. Resembling a raceme.
Rachis. The central axis of a spike or raceme of flowers or of a compound leaf.
Radial. Radiating, as from a center, i. e., as from the pith.
Radial-section. A longitudinal-section of a body which passes through its center, as the pith of a twig or log. Page 195, VIII, e.
Ray. I. e., medullary ray.
Ray cell. A cell of the medullary ray.
Ray tracheid. A tracheid found in the medullary rays of some trees.
Recurved. Curved downward or backward.
Resin cell. A cell which secretes resin.
Resin duct. A canal or opening between cells containing fluid resin.
Reticulate. Netted.
Rhombic. Equilateral, with the angles oblique.
Ring. Meaning growth ring.

Ring-porous. Said of wood whose large pores are collected into a row or band in each growth ring.
Rough. Harsh to the touch; pubescent.
Rugose. Wrinkled.

Samara. An indehiscent winged fruit.
Sapwood. The living outer portion of a trunk or large branch of a tree between the heartwood and the bark. Page 195, VIII, b.
Scalariform. Having markings suggestive of a ladder.
Scales. Small modified leaves, usually thin and scarious, seen in buds and cones; the flakes into which the outer bark often divides.
Scaly. Provided with scales.
Scar. See leaf-scar.
Scarious. Thin, dry, membranaceous; not green.
Scurfy. Covered with small bran-like scales.
Seed. The ripened ovule.
Sepal. One of the divisions of a calyx. Page 8.
Seriate. Disposed in series or rows.
Serrate. Toothed, the teeth sharp and pointing forward. Page 8.
Sessile. Without a stalk.
Sheath. A thin enveloping part as of a leaf, any body enwrapping a stem.
Shrinkage. A contraction of any material, as wood, into less bulk or dimensions.
Shrub. A bushy, woody growth, usually branched at or near the base, less than 15 feet in height.
Silhouette. A drawing having its outline filled in with uniform color, commonly black.
Simple. Of one piece; not compound.
Sinuate. Strongly wavy. Page 8.
Sinuous. In form like the path of a snake.
Sinus. The cleft or space between two lobes.
Smooth. Smooth to the touch; not pubescent.
Spatulate. Wide and rounded at the apex, but gradually narrowed downward. Page 7.
Sphagnous. Resembling or allied to the genus *Sphagnum*, a moss.
Spike. A simple inflorescence of sessile flowers arranged on a common, elongated axis (rachis). Page 9.
Spine. A sharp woody outgrowth from a stem.
Spirally. As though wound in a spiral around an axis.
Spirals. A term applied to the spiral thickenings of tracheids and vessels. Page 195, IX, c.
Spontaneous. Self-planted or generated; wild or sporadic; growing without human agency.
Spray. The aggregate of smaller branches and branchlets.
Spring wood. The wood produced early in the growing season, characterized by larger ducts and cells and thinner walls than the later growths possess; the inner portion of each annual increment.
Spur. A hollow sac-like or tubular extension of some part of a blossom.
Stamen. The pollen-bearing organ of a flower, normally consisting of filament and anther. Page 8.
Staminate. Provided with stamens, but usually without pistils.
Staminodium. A sterile stamen.
Sterile. Unproductive, as a flower without pistil, or a stamen without anther.
Stigma. The part of a pistil which receives the pollen. Page 8.
Stipules. Leaf-like appendages on either side of a leaf at the base of the petiole.
Stipule-scar. The scar left by the fall of a stipule. Page 10.
Striate. Marked with fine longitudinal stripes or ridges.
Strobile. A cone.
Style. The part of a pistil connecting ovary with stigma. Page 8.
Sub-. A prefix applied to many botanical terms, indicating somewhat or slightly.
Subtend. To lie under or opposite to.
Sucker. A shoot arising from a subterranean part of a plant.

Summer wood. The wood produced late in the growing season, characterized by smaller ducts and cells and thicker walls than the earlier growths possess; the outer portion of each annual increment.
Superposed. Placed above, as one bud above another at a node.
Suture. A junction or line of dehiscence.

Tangential. At right angles to the medullary rays.
Tangentially. In a tangential manner.
Tangential-section. A longitudinal-section of a body at right angles to any one of its radii; any longitudinal-section of a tree trunk which does not pass through the pith. Page 195, VIII, f.
Terete. Circular in cross-section.
Terminal. Situated at the end of a branch.
Ternate. In threes.
Tetrahedral. Having, or made up of, four faces (triangles).
Texture. The disposition, arrangement or character presented by the different elements in the structure of the wood.
Thorn. A stiff, woody, sharp-pointed projection.
Thyrse. A contracted or ovoid and usually compact panicle.
Tissue. The texture or material built up by the union of cells of similar origin and character.
Tolerant. Capable of enduring more or less heavy shade.
Tomentose. Densely pubescent with matted wool.
Toothed. With teeth or short projections.
Torus. The part of the axis of a flower which bears the floral organs.
Trachea. A duct or vessel. Page 195, IX, b.
Tracheid. A long, slender cell, with closed ends and its walls thickened after the cell has attained its full size. Page 195, IX, a.
Transition. Change as from spring wood to summer wood.
Transverse. Said of a wood section made at right angles with the axis of the stem; across the grain.
Tree. Usually defined as a plant with a woody stem, unbranched at or near the base, reaching a height of at least 15 feet.
Trunk. The main stem of a tree.
Turbinate. Top-shaped.
Tylosis. A growth, frequently exhibiting repeated cell-division, intruding within the cavity of a duct or vessel from the wall of a contiguous growing cell.

Umbel. A simple inflorescence of flowers on pedicels which radiate from the same point. Page 9.
Umbellate. Arranged in umbels.
Undulate. With a wavy margin or surface. Page 8.
Uniseriate. In one horizontal row or series.
Unisexual. Of one sex, either staminate or pistillate; not perfect.

Veins. Threads of fibro-vascular tissue in a leaf, petal, or other flat organ.
Vessel. A duct or jointed tube which becomes continuous by the more or less complete absorption of the intervening cross-walls. Page 195, IX, b.
Villose or *Villous.* Covered with long, soft hairs.
Viscid. Glutinous; sticky.

Warp. To become uneven in outline, as by shrinkage; to become twisted or distorted out of shape.
Whorl. An arrangement of leaves or branches in a circle round an axis.
Wing. Any membranous or thin expansion bordering or surrounding an organ.
Wood. The hard part of a stem lying between the pith and the bark.
Wood elements. The cells or units making up the wood.
Wood fibers. Long, slender cells with thick walls and narrow cavities, which impart strength and toughness to the wood and bark. Page 195, IX, d.
Wood parenchyma. A several-celled fiber in which the end cells have pointed extremities while the intermediate cells have square ends. Page 195, IX, e.
Woolly. Covered with long and matted or tangled hairs.

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ment is paid for with fertilizer control funds. In no way whatsoever, directly or indirectly, are the federal funds used for this purpose. One hundred and sixty-eight brands, the output of 18 companies, were analyzed and with a few exceptions were found to be as good as they were said to be.

2. *Commercial feeding stuffs.* The small appropriation for this work, less than that made in any other state, necessitates an inadequate control of this trade. Nearly 700 samples have been drawn and analyzed for protein only. The outcome was a very unsatisfactory one, a large number of feeds being seriously deficient. The Station is able to purvey much general information in its feeding stuff bulletins.

3. *Creamery glassware and operators.* The volume of this line of work has been fairly uniform. Several thousand pieces of Babcock glassware, mostly cream bottles, were tested. The proportion of inaccurate glassware is quite small. A few would-be licensees were unable to pass an adequate examination and licenses were refused.

4. *Agricultural seed.* About 350 samples were collected in 1915 and nearly 500 in 1916. These have been tested, the results appearing in bulletins 192 (1915) and 200 (1916). Guaranties were omitted on one-seventh of the 1915 sales; were not made good in fact in one-twentieth of the samples; and 14 lots of timothy and red top were found to be ergotized.

FORESTRY

The experimental work for the past year has been along two lines:

1. *Permanent sample plot work.* These sample plots have been located in the University woodlot at Burlington, and on the state forests at Plainfield, West Rutland, Proctorsville and Townshend. In each case one or more experimental plots have been established and the check plots to accompany same. The plots are 100 feet square with isolation strips surrounding them. Each tree has been carefully located, the crown mapped in and the circumference measured. On each of the larger plots two or three sub-plots, ten feet square each, have been carefully mapped in order to study reproduction. Each season these sub-plots are carefully resurveyed and the number of seedlings of every kind of plant which comes into the plot tabulated. In this way we shall be able to formulate some very definite information as to what takes place under different conditions of light, moisture, etc. It is understood that this study is of a permanent nature and that the longer the experiment is continued the more satisfactory

will be the results. It may be possible, however, during the coming winter, to issue a preliminary statement of this work.

2. *Hardwood study.* The object of this study is to determine a more efficient and accurate method of estimating old growth hardwoods, especially in culled stands. It has been found that all available volume tables give very unsatisfactory results. The study is following the lines which have been worked out by Scheffel of Germany and Jonson of Sweden. The result will be either volume tables classified not only in height diameter classes, but also form classes, or else mathematical formulas which will enable the estimator to make local volume tables for any particular stand which he may be estimating. Very careful volume measurements are being made of hardwood timber wherever cutting is being done. The volumes, form factors, and form quotients of all of these trees are carefully computed. If possible, mathematical relationship between form factor, form quotient and volume will be determined. If the mathematical law cannot be discovered, these different factors will be arranged in tables.

HORTICULTURE

The work of the horticultural department of the past year has been devoted to a further prosecution of the following projects:

1. *Forcing plants with carbon dioxid.* The problem was that of determining the effect of the artificial application of this gas to various horticultural plants. Especial attention this past year has been given to the determination of optimum applications, computations on chemical modifications of treated plants, and preparation of manuscript for publication.

2. *Sterility of strawberries.* Many varieties of strawberries are self-sterile because of their unisexuality. The project called for a study of the causes and remedies of this sexual imperfection. Breeding experiments have started to study the behavior of sexes in crossed and uncrossed progeny. The record generation plants have been secured, and the third generations crosses are being made. Nutrition experiments are also under way with a view of studying the effect of varied feeding upon sex characteristics.

3. *Cion selection.* The study of the effect if any of the selection of cions from parent trees of superior or inferior fruiting habits which was started several years ago has been continued during the past year. Many of the cions are coming to a bearing age and their ca-

SIXTH

ANNUAL REPORT

OF THE

STATE FORESTER

PROGRESS OF FORESTRY IN VERMONT

AUSTIN F. HAWES
State Forester

1914

ST. ALBANS, VT.:
ST. ALBANS MESSENGER COMPANY
1914

TO THE GENERAL ASSEMBLY OF VERMONT.

In compliance with Section 2 of Act No. 11 of the Acts of 1908, I take pleasure in submitting my report on the Progress of Forestry in Vermont.

AUSTIN F. HAWES,
State Forester.

Burlington, Vermont, August 1, 1914.

A GOOD STAND OF SECOND GROWTH SPRUCE, ROCHESTER, VERMONT.

THE MAINTENANCE OF THE LUMBER BUSINESS OF VERMONT REQUIRES FOREST CONSERVATION.

INTRODUCTION.

Perhaps the largest non-political gathering of Vermonters of recent years was on the occasion of the last annual meeting of the Greater Vermont Association at Burlington. At this meeting several notable addresses were made relative to the future development of Vermont. It was a striking fact that all of the speakers were unanimous in the opinion that the prosperity of Vermont depends upon the development of agriculture and forestry. Hon. Charles Prouty and Hon. T. N. Vail, men thoroughly acquainted with the State, and looking at matters from an entirely different angle, each laid special stress on the need of forest conservation in Vermont.

While the practice of forestry is still far behind the general interest in the subject, the increased demands upon the Forestry Department for inspection of woodlands, for general advice, and for nursery stock, and the growing interest in State ownership of large tracts, all characterize an encouraging condition.

In a few sections of the State, however, destructive lumbering is progressing on a scale hitherto unknown, and unless prompt steps are taken, considerable areas of Vermont will be turned from productive forests to worthless barrens. The reactionary policy of these large concerns, which pay no heed to the future, force one of two alternatives upon the people. Either the State must assert its right to regulate the cutting of these mountain forests, or it must embark more extensively upon the policy of State ownership. Neither can be adopted without increased appropriations, and at present the policy of purchase seems the better, although possibly the slower method.

LEGISLATION RECOMMENDED.

In 1913 twenty percent of the forest fires were attributed to railroads. Besides these, probably some of the fires, whose causes were given as unknown, may be attributed to railroads. In view of this fact, the following law, based upon the Connecticut Law, is proposed:

I. Sec. 1. Any railroad company which, through any act of its employees or agents, by sparks from its locomotives, or otherwise, sets fire to trees, brush, or grass, on lands outside the right of way of such company, shall be liable to the town or city in which such fire occurs for the lawful expenses incurred by such town or city in extinguishing such fire.

Sec. 2. A bill for such expenses shall be rendered by the local fire warden having charge of the extinguishing of such fire, and upon approval of such bill by the State Forest Fire Warden, and upon presentation thereof to the chief engineer of the railroad company liable for such expenses under the provisions of Section One of this Act, such expenses shall be paid by said railroad company.

Sec. 3. It shall be the duty of every section foreman employed by a railroad company, upon the discovery of any fire, in the section under his jurisdiction, for which said company is liable under the provisions of Section One of this Act, to summon necessary assistance, proceed to the fire and extinguish it, and to give such assistance to the town or district fire warden as may, from time to time be requested by such warden. **[As most of these railroad fires start in slash resulting from lumbering near the railroad, there should be a law similar to one recently passed in Massachusetts.]**

II. Sec. 1. Every owner, tenant or occupant of land, and every owner of stumpage who cuts or permits the cutting of wood or timber on woodland owned or occupied by him or on which he has acquired stumpage by purchase or otherwise, and which borders upon a railroad location, shall clear the land of the slash and brush wood then and there resulting from such cutting, for a distance of one hundred feet from the right of way, and within four months of the cutting on this strip.

Sec. 2. Whoever neglects to comply with the conditions of Section One, of this Act, may be punished by a fine of not less than five dollars nor more than one hundred dollars.

TAXATION.

It is expected that after January 1, 1915, many land owners will take advantage of No. 41 of the Acts of 1912, and have their lands classified and taxed under it. This law is not ideal, and was only passed to relieve land owners, while at the same time safeguarding the interests of the towns. Owners should eventually classify as much of their land as possible under No. 40 of the Acts of 1912. In other words, as soon as a piece of woodland classified under No. 41 is cut off and reforested, either naturally or artificially, it should be reclassified under No. 40. Where a whole lot is thus reclassified there can be no chance for a mistake. Where only a part of a lot is thus reclassified there is no provision in the law for deducting the value of the amount thus cut from the total value assessed under No. 41.

III. An amendment to No. 41 should provide that when any portion of land classified under this law is cut off and reclassified under No. 40, that the value of the timber or wood cut, as taxed under No. 41, shall be deducted from the assessable value of the area remaining under No. 41 (provided the remaining value is not less than $5 an acre).

For example, if 100 acres were classified under No. 41, and assessed at $2,500 and after a period of years 40 acres were cut off and produced $1,000 worth of stumpage upon which a yield tax was paid, this 40 acres, when reproduced, could be classified under No. 40 and assessed at $3 an acre. The remaining 60 acres would then be assessed under No. 41 at $2,500—$1,000=$1,500.

STATE FORESTS.

The appropriation for the purchase and reforestation of State forests should also be available for cuttings, so that demonstration thinnings might be made wherever practicable. Since money spent on State forests is an investment which will, in time, produce a revenue, it is recommended that the small appropriation made for this purpose be increased to $15,000 a year. Massachusetts, in which forestry is far less important than in Vermont, has appropriated $20,000 annually for similar work.

WATER POWERS.

At the request of Governor Fletcher, the writer represented the State at the Conservation Congress held in Washington, D. C. in December 1913. The subject of chief interest at this Congress was the public control of water powers. The report of the Congress on this subject, as finally accepted by a sweeping majority of those present, provides as follows:

"We recommend that the following principles should govern the granting of a privilege to use a water power.

(a) For a definite period, sufficient to be financially attractive to investors, the privilege should be irrevocable except for cause, reviewable by the courts:

(b) Thereafter the privilege should continue subject to revocation in the absolute discretion of the government exercised through its administrative board or officer upon giving reasonable notice and upon payment of the value of the physical property and improvements of the grantee as below provided under (h).

(c) After the expiration of the period provided for in (a) above, at recurring intervals of not more than ten years the amount of compensation to be paid to the government for the privilege and all the terms and conditions of the grant during the next succeeding period of not more than ten years shall automatically come up for determination by the granting officer of the government.

(d) The privilege shall be unassignable except with the approval of the government in order to safeguard the interests of the government against speculation in water powers and against appropriation without prompt development.

(e) The privilege shall be granted only on condition of development of the whole capacity of the power site as rapidly as the granting officer may from time to time require, giving due consideration to reasonable market demands and conditions and also on condition of continuous operations subject to such demands and conditions.

(f) The right to receive compensation for the value of the privilege varying according to the proper conditions of each case shall be reserved to the government, state or federal from whom the privilege comes. We believe that the reservation of such a right to compensation is a vital essential towards the end of proper regulation. It is not sufficient to trust that the public will always receive its proper share by means of regulation of rates alone. Local authorities may neglect or may be unable, under conflict of jurisdiction, or for other reasons, to exact in the interest of the public the full value of the public right. The value of a water power may in the course of time increase far beyond the power of local regulation to adequately distribute its benefits At the same time, the method of exacting compensation must be carefully safeguarded so that in case full compensation by rate regulation is exacted by local authorities, an additional burden shall not be imposed. We believe that in normal cases the best method is for the government to share increasingly in the net profits of the enterprise, provided those profits exceed a certain reasonable percentage, the right of the government being recognized otherwise merely by the imposition of a small annual fee or its equivalent.

(g) The government shall have the right to prescribe uniform methods of accounting for the grantee and to inspect its books and records.

(h) Upon revocation of a privilege by the government the grantee shall be paid a compensation equivalent to the fair valuation of its property, exclusive of franchise and consequential damages; this compensation shall include such appurtenances as are necessary for the operation of the water power and the transmission of electricity therefrom but shall not include such properties as railroads, lighting systems, factories, etc., which are of themselves separate industries.

In such transfer all contracts for the sale or delivery of power made in good faith previous to such notice of transfer should be assumed by the transferee so that the said grantee may operate and maintain the power business during his occupancy of the property under such stable guarantee as may beget confidence therein by prospective long term contractors, provided, that the government or said transferee shall not assume any contracts made at a price or under conditions which shall be determined by the proper administrative officer of the government to be unreasonable or confiscatory.

GEORGE F. SWAIN, Chairman.
GIFFORD PINCHOT,
HON. HENRY L. STIMSON,
LEWIS B. STILLWELL,
CHARLES R. VAN HISE,
M. O. LEIGHTON,
E. S. WEBSTER,
B. M. HALL.

EDUCATIONAL WORK.

As explained later, the chief progress of the year has been due to the greater demand for personal advice on the handling of woodlands. This was undoubtedly greatly stimulated by the forest conferences held during the summer and fall of 1913. A forest conference consisted in an illustrated lecture on forestry in the evening, followed the next forenoon by a field trip into some woodlot. Conferences were held only in places where a guarantee of at least ten people for the field meeting could be obtained. The writer wishes to express his appreciation for the cooperation in the arrangement of these conferences, of the county agricultural advisors, especially Mr. Sweeton in Windham County, and Mr. Demary in Orange County.

Conferences were held in: West Woodstock, North Thetford, Topsham, East Burke, Greensboro, Stowe, Middlesex, Worcester, Calais, Enosburg, Berkshire, Wilmington, East Dover, Wardsboro, Townshend, East Braintree, Chelsea, West Topsham, Glover, Bristol, Westfield, West Charleston, East Charleston, Barnet, Springfield, Athens, Windham, Norwich and Duxbury. Altogether, about 2,000 people attended these meetings.

The plan of the conferences the present season is somewhat different from that of 1913. More emphasis is placed on the field work and less on the indoor meeting. Arrange-

A FOREST CONFERENCE ON THE ARLINGTON STATE FOREST—1914.

A FOREST CONFERENCE IN WINDHAM COUNTY IN 1914.

ments are being made to supply a forestry expert for one week to each county advisor. By the use of the latter's automobile it will be possible to hold two field meetings a day several miles apart.

In addition to the conferences, addresses on forestry were given at the institutes held by the Commissioner of Agriculture at the following places:

Chelsea, West Newbury, Danville, Sheffield, Newport, Barnard, Westminster, Vernon, Shaftsbury, Rupert, West Haven, Shoreham, Starksboro, Charlotte, Moretown, North Craftsbury, Cabot, Bakersfield and Cambridge.

In cooperation with the Extension Department of the University of Vermont and State Agricultural College, forestry lectures were given at the schools held at Thetford, Jericho, St. Johnsbury, Hartford, Bristol, Pittsford, Fairhaven, Morrisville, Dorset and Grand Isle.

The State Forester also delivered addresses on forestry at the following meetings:

Annual Convention of the Universalist Church at Rutland; Annual Meeting of the Vermont Sugar Makers Association at Rutland; Conferences held by the Bennington Co. Improvement Association at Bennington, Manchester and East Arlington; Congregational Brotherhood, Burlington; State Engineers Annual Meeting at Burlington; Board of Trade, Swanton; Merchants Association, Burlington; and meetings held under the auspices of the Y. M. C. A. at Vergennes and Middlebury.

Schools for the forest fire wardens were held in the spring of 1914 at Brattleboro, Wells River, Montpelier, Lyndonville and Middlebury. Through the generosity of Mr. C. M. Darling, the Lyndon Warden, the wardens attending this meeting were carried to the State forest plantation, in which they were much interested, and also entertained at dinner.

The third summer school of Horticulture and Forestry was held on the Charles Downer State Forest in August, 1913, and was more largely attended than in the previous season. In connection with this a very successful Sharon Day was held which was well attended by people of Sharon and surrounding towns. Addresses were made by His Excellency, Governor Fletcher, and President G. P. Benton of the University of Vermont.

The practice of furnishing exhibits at fairs was continued. Exhibits were shown at Middlebury, Rutland, St. Johnsbury, White River and Brattleboro.

Since issuing the last report, there have been published by the office, the following:—

Publication No. 13. "The Management of Second Growth Hardwoods in Vermont"—Bulletin 176 of the Vermont Agricultural Experiment Station. This bulletin, which is the result of a two years' study of second growth hardwoods, should form the basis of management of such lands. It contains the following parts:

Part I. Estimating the Contents of a Woodlot.

Part II. Improvement of the Stand.

Part III. Yield Tables.

Part IV. Crop maturity, and the Selection of the Crop.

Part V. Market Conditions.

Part VI. Enemies of Our Northern Hardwoods.

Appendix containing Volume Tables and Curves.

Publication No. 14. A Forestry Arithmetic for Vermont Schools. The introduction of this bulletin is as follows:

TO THE TEACHER.

Forestry, as a branch of agriculture, has made remarkable progress in the past few years. People are beginning to see that the old way of considering the forest as a mine to be exploited is wrong, and that the forest should be considered as a growing crop to be protected, improved, harvested and grown again just like corn or grass, except for the length of time necessary to grow a crop. The older people have adopted this new attitude even more than could have been expected of them, considering the length of time required to grow timber. But it is with the future generation that the practice of forestry must be expected. It is, therefore, necessary to instruct and interest the young in the principles of forestry. Several books have been written with a view to giving forestry instruction that can be understood by children. Much can be accomplished indirectly through suggestion. Teachers have long recognized the value of using text books in such subjects as arithmetic and grammar, based upon the facts of country life. The purpose of this bulletin is to give the Vermont teacher some examples in arithmetic which can be used to supplement the regular text book used, and which will suggest to the scholar many of the important forestry ideas which it is desirable for our young to have.

At the end of the bulletin are reprinted some forestry experiments originally prepared by the writer for a bulletin published by the State Commissioner of Education.

Publication No. 15. This is Bulletin 181 of the Vermont Agricultural Experiment Station—"Studies of Tolerance of New England Forest Trees," by Prof. G. P. Burns.

Forestry Card No. 17 March 1, 1914

VOLUME TABLE OF OLD GROWTH HARDWOODS

Diameter breast high	Beech Total Volume	Beech Number of trees tallied	Yellow Birch Total Volume	Yellow Birch Number of trees tallied	Sugar Maple Total Volume	Sugar Maple Number of trees tallied
Inches	Bd. Ft.		Bd. Ft.		Bd. Ft.	
13	83	12	59	7	81	5
14	115	55	95	16	119	14
15	142	52	125	23	142	28
16	167	56	146	32	162	18
17	189	44	163	32	184	34
18	211	46	186	57	207	33
19	240	25	217	50	232	20
20	275	24	250	39	255	28
21	314	16	297	40	283	16
22	359	5	331	46	319	22
23	414	6	363	25	354	18
24	473	4	388	37	382	9
25			408	30	410	9
26			434	24	430	4
27			470	28	445	5
28			505	16	447	3
29			545	4		
30			588	12		
31			619	4		
Total		345		522		266

This table was made in Herkimer Co., N. Y., by E. A. Braniff, from band and circular saws. See Bulletin 36 U. S. Forest Service. Appendix.

Forestry Card No 18. March 1, 1914

COMPARATIVE GROWTH OF FIVE VERMONT TREES

Age Years	White Pine	Yellow Birch	Sugar Maple	Beech	White Ash	Paper Birch
Diameter in inches.						
20	5.3	2.8	2.5	2.0	4.1	3.4
40	11.3	5.5	5.1	3.9	7.9	6.8
60	15.	7.9	7.5	6.1	10.8	8.9
80	18.	9.6	9.3	7.9	12.6	10.2
Height in feet						
20	24	35	33	25	39	30
40	53	51	50	41	63	54
60	73	61	60	50	77	68
80	84	68	67	58	86	78

The above figures are averages for trees grown under ordinary forest conditions. They do not indicate the maximum obtainable under favorable condtions. See Bulletin 176 of the Vermont Agricultural Experiment Station.

Forestry Card No. 19. March 1, 1914*

YIELD TABLE PER ACRE SECOND GROWTH HARDWOODS IN VERMONT. LUMBER AND CORDS

	QUALITY I		QUALITY II		QUALITY III	
Years	Lumber Bd. ft.	Cords in addition to lumber	Lumber Bd. ft.	Cords in addition to lumber	Lumber Bd. ft.	Cords in addition to lumber
20		17.4		14.4		10.9
30		25.6		20.8		15.6
40	3500	24.1	2000	21.2	1000	17.1
50	9900	22.9	4500	22.9	3000	21.2
60	13800	20.6	8200	22.6	6600	17.6
70	15100	18.8	10900	20.6	9100	16.2
80	15800	18.2	12800	19.4	10600	15.9

NOTE—Lumber scaled by Vermont Rule with no allowance for rot or crook to 6 inches diameter outside bark at top end. In applying the above table the percentage of sound trees to unsound trees of lumber size on a lot should be estimated and the proportion applied to the amount of lumber given in the table. In converting cubic feet to cords, 85 cu. ft. of solid wood equals 1 cord. A **yield table** gives the average yield per acre produced in different lengths of time. A **volume table** gives the average volume of individual trees of different sizes. This yield table is taken from Bulletin 176 of the Vermont Experiment Station.

Forestry Card No. 20 March 1, 1914

MERCHANTABLE VOLUME OF POPLAR IN CUBIC FEET INSIDE BARK BY DIAMETER AND HEIGHT

Diameter outside bark breast high	Height of tree in feet						
	30	40	50	60	70	80	90
	Volume in cubic feet						
5	0.5	1.0	1.5	2.0	3.0	....	....
6	2.0	2.5	3.0	3.5	4.5	6.0	....
7	3.5	4.0	4.5	5.5	7.0	8.5	....
8	5.5	6.0	7.0	8.0	10.0	11.5	13.0
9	...	8.0	9.5	11.0	12.5	14.5	16.5
10	...	10.5	12.0	14.0	16.0	18.0	20.0
11	...	....	15.0	17.0	19.0	21.5	25.0
12	...	....	18.0	20.5	23.0	26.5	30.0
13	...	....	....	24.0	27.0	31.5	36.0
14	...	....	....	28.5	32.0	37.0	43.0
15	...	....	....	32.0	37.0	43.0	51.0
16	...	....	....	37.0	43.0	50.0	59.0
17	...	....	....	43.0	49.5	57.0	68.0
18	...	....	....	....	57.0	66.0	76.0
19	...	....	....	....	65.0	75.0	85.0
20	...	....	....	....	74.0	84.0	95.0

*See Bulletin 93 by Weigle & Frothingham of U. S. Forest Service. This table was based on the measurements of 362 trees in Maine. To convert to cords, divide by 85 because a stacked cord contains about 85 cu. ft. of wood.

Forestry Card No. 21 March 1, 1914

TOTAL STEM VOLUMES OF PAPER OR WHITE BIRCH, BASED ON MEASUREMENTS OF 443 TREES IN MAINE AND EASTERN NEW HAMPSHIRE

Diameter breast high	Height of tree 50 feet	 60 feet	 70 feet	 80 feet	 90 feet
	Volume				
Inches	cu. ft.	cu. ft.	cu. ft.	cu. ft.	cu. ft.
4	2.5	3.0	....	....	....
5	3.7	4.3	4.8	....	....
6	5.2	5.9	6.7	7.8	...
7	6.8	7.8	9.0	10.4	12.2
8	8.9	10.2	11.5	13.3	15.3
9	11.2	12.8	14.5	16.5	18.8
10	14.0	15.9	18.0	20.4	22.8
11	17.2	19.5	21.8	24.6	27.5
12	20.0	23.4	26.3	29.5	33.0
13	....	28.0	31.5	35.3	39.6
14	....	33.0	37.3	42.1	47.4
15	....	38.9	44.0	49.7	55.8
16	....	....	51.0	57.5	60.0

See Circular 163 by S. T. Dana, of U. S. Forest Service.

Forestry Card No. 22. March 1, 1914.

The spring of 1914 is the time for the quadrennial appraisal of real estate. Assessor should remember that a high valuation of standing timber stimulates cutting and means a permanent loss to the town.

	ACRES 1000	 150	 50
	Case 1 1% tax	Case II 1%tax	Case III 1%tax
A fair valuation on a tract	$30,000	$24,000	$18,000
Town's income for 10 yrs. on fair valuation	$ 3,000	$ 2,400	$ 3,600
An over valuation which forces owner to cut	$40,000	$30,000	$20,000
Period taxed on this high valuation before cut	2 yrs.	2 yrs.	3 yrs.
Tax on this vauation until cut	$ 800	$ 600	$ 1,200
Period taxed on low valuation after cutting	8 yrs.	8 yrs.	7 yrs.
Assessed value per acre after cutting	$ 1	$ 2	$ 6
Tax on land after cutting	$ 80	$ 24	$ 42
Sum of tax at high valuation for short time and low tax on cut-over land for remainder of period of 10 years	$ 880	$ 624	$ 1,242
Loss to town because of this high valuation	$ 2,120	$ 1,776	$ 2,358

Low valuation of timberland encourages owner to cut according to forestry principles, and to leave young timber standing.

Clear cuttng means loss of permanent industries; the income producing ability of land destroyed; loss in water power; increased erosion; and a higher tax rate.

ADVICE TO PRIVATE OWNERS OF FORESTS.

By far the most encouraging sign of progress in forestry, during the past year, has been the increase in requests for inspections of woodlots. While it can hardly be expected that all those receiving advice will follow it to the letter, reports indicate that most of those visited have at least commenced to put the advice in practice. Hereafter the rules under which inspection of private lands is made, will be as follows:

1. The Forestry Department does not estimate timber for private owners.

2. The Department will send one or more men to inspect any land in the State, and advise on its management. The only cost will be that of travelling expenses to and from Burlington, and board while doing the work.

3. A report on the work, done under the recommendations of the previous inspection, will be required before another inspection will be made.

4. The Department will supervise the marking of trees which should be cut. On tracts of less than ten acres the owner will be expected to furnish one man; on larger tracts two men.

5. The Department reserves the right to publish the reports on such inspections, and the results of work done under such recommendations.

Thinking that the reports on inspections of woodlands may have a general interest for others owning similar lands, extracts from these reports are given below:

1. Land owned by A. J. Eaton.
Town—South Royalton.
Area—100 acres.

Recommended a regular thinning of a young white pine stand; a very careful selection cutting in open field stand; a clear cutting of hemlock, followed by planting pine; and a regular thinning of hardwoods; the cutting out of inferior species and underplanting with pine where resulting stand was very open in a mixed stand of soft and hardwoods, and keeping stock out of whole area. The owner had done some very good work thinning a white birch stand, and a mixed hardwood stand.

2. Land owned by Rutland Country Club.
Town—Rutland.
Area—Probably 70 acres.

Type description.—Burned over land on Pine hill. Scattered pine growth on a gravelly pasture. Recommended—Cutting of mature pine without regard to natural reproduction. Burned land should be planted provided sufficient fire protection can be provided. Area east of the brook should at least be planted. The gravel pasture knoll should also be planted, but may be used for pasture for a few years. The best pasture should be improved as pasture land. All the swamp should be cleared and drained for agricultural purposes.

3. Land owned by E. J. Handley & Sons.
Town—East Granville.
Area—20 acres.

Type description.—The land in question is rocky pasture on a steep hillside. It is partly seeded to spruce of all ages with a few scattering pine. It is recommended that cattle be excluded so that this land may be planted with white pine where it is not already seeded. By doing some planting each year the open areas which have been cut clear, can be restocked within a comparatively short time. The areas which can be planted the cheapest, should be taken in hand first. The oldest spruce should be cut by the strip system, avoiding especially young stands and favoring, even in the strip cut, the white pine. The younger stands where the trees are very nearly even aged, should be thinned at the same time, if market conditions will permit, that is, if the material removed in thinning will at least pay for the cost of removing. This strip system consists in cutting out strips of spruce perpendicular to the direction of the prevailing wind, or, if necessary, in order to log economically, up and down slopes. They should be as narrow as can be cut economically, if possible not over 50 feet wide. At most they should not be any wider than twice the height of the remaining trees. The width of the uncut strips will depend upon the danger of wind-fall, but probably should not be any narrower than the cut strips.

4. Land owned by J. N. Johnston.
Town—West Brattleboro.
Area—20 acres.

Type description.—The open land, which consists of about 70 acres, should be planted with white pine, taking about five years to cover the whole area. The land least valuable for pasture should be planted first, especially the area where the hard-hack is extremely rank. When this area is planted where the growth of hard-hack is so strong, it will be necessary to either plow furrows six feet apart with an ox team, or send a man ahead of the planting crew trimming out hard-hack on the spaces where the trees are to be set, thus giving the mattock-man a chance to clean out roots. With a heavy plow and ox team available, planting in the bottom of furrows would probably be most satisfactory. The hardwood land does not need immediate attention, although some fire wood can be removed from this and still improve the stand. From the area of old field spruce with the overstory of hardwoods, the hardwoods should be cut for fire wood as soon as possible, as they are whipping the tops of the better trees. The older stand of old field spruce should be marked for an improvement cutting, removing the trees which are badly diseased with red rot.

5. Land owned by Arthur Palmer.
Town—Thetford. Date of inspection July 28th, 1913.
Area—100 acres.

Type description.—Various types on a steep slope. On one patch of second growth pine an improvement thinning was recommended. Another similar patch of pine and spruce had been badly thinned by the owner. Instead of removing smaller and suppressed trees, as should be done in a thinning, and leaving large healthy trees to grow to maturity, the owner treated the lot as if it were mature, and removed the best and largest trees. The remaining suppressed trees have such small tops that good growth is impossible. It was, therefore, recommended that they also be cut and the area replanted. In another portion, where hardwoods and pine were mixed, the owner had removed the hardwoods, thus producing a good condition for the natural reproduction of pine from the remaining trees.

6. Land owned by C. C. Putnam & Son.
Town—Middlesex. Date of inspection July and October, 1913.
Area—200 acres

Type description.—Two types on slope east of Putnamville. On top of ridge a culled virgin forest of beech, yellow birch, maple, scattered spruce, basswood and ash. Below a westerly slope second growth hardwoods on land used for farming some 50—60 years ago. Second growth comprises some splendid poplar 10″ to 18″; yellow birch, white ash, soft maple, etc. Selection system used on upper ridge. There was hardly anything fit to leave, but some spruces surrounded by hardwoods were left. It is hoped that some reproduction of spruce, ash and basswood will result, and interplanting of the openings with pine after cutting was recommended. In second growth stand—preparatory cutting of shelter wood system was used. All poplars were marked and much of maple, beech, etc. Most of the ash was left to reproduce. Perhaps 2-3 of the volume was marked. From the upper lot there was cut, during the winter 1913-'14, as a result of this marking:

79,009 feet of spruce,
83,825 feet of hardwoods.

From the lower lot:

36,976 feet of spruce,
74,659 feet of hardwoods.

In June 1914 a continuation of both cuttings was marked. On the upper lot the cutting in 1914 will be on the east slope instead of the west, as last year. The top of the slope was marked for a clean cutting.

7. Land owned by Mrs. G. Day.

Town—Greensboro. Date of inspection Aug. 6th, 1913.
Area—20 acres.

Type description.—This is a narrow strip of land along the shore of Caspian Lake, and is very low and swampy, with the exception of a knoll of shallow soil. The owner wishes to transform this poor pasture into forest, and was advised to plant four-year white pines. In the mature timber a very conservative cutting was recommended, removing the soft woods which are diseased with red rot. Several of the large pine are diseased. The openings made by this cutting should then be planted with Norway spruce, which is able to withstand more shade than pine.

8. Land owned by Nelson & Hall.

Town—Montgomery. Date of inspection Sept. 1913.

Area—3000 acres.

Type description.—The type is mostly hardwood land which has been culled of its spruce and is about to be lumbered for hardwoods. The hardwood trees are the only ones which can be taken into consideration, as the spruce are very scattering and should be cut unless they have very well shaped crowns and an opportunity to grow free from the suppression from hardwoods, and are free from the red rot. One of these three things will demand the cutting of most of the scattered spruce. The hardwood consists of five classes: (1).—The old mature trees which have gone by, and some of which are almost valueless; (2).—The mature trees, which, considered from their merchantable value alone, are ready to be cut, and are the most valuable part of the stand; (3).—The immature trees which have well shaped crowns, are sound and growing rapidly; (4).—Poorly shaped trees which have been crowded by the others until they have small crowns, crooked knotty trunks, and are growing very slowly, and

(5).—Young growth. To leave this land in its best shape to earn its greatest possible income, all of the third class should be left and enough of the second to prevent drying out of the soil to such an extent as to kill the other trees which are left and to prevent windfall among the remaining trees, and to furnish seed for the next crop. The method of conservative cutting which has been in operation for the last season on this land, has resulted in such an open stand that the soil has dried out excessively, and too much of the fourth class has been left. More of the second class should be left and this fourth class cut out as closely as market conditions will permit, because only the good, straight boled, well crowned trees properly spaced can make this land earn the income in tree growth that it is capable of earning. Where the profit in logging is so slight that it is necessary to remove a large percentage of the second class, the land should either be cut clear where natural reproduction has already taken place, or the fourth class may be left for shade to prevent windfall and drying out of the soil in order to get the additional growth on the third class. This, however, will result in a very small income from the land as compared with what it is capable of producing if it could be cut in the other way. In a few places, where there is very little of the third class, or in the mixture where more reproduction is started, a clear cutting which would give this young growth an opportunity, is the wisest policy.

Manufacture of by-products, which enables the utilization of this inferior crooked, knotty, low grade lumber, which makes up the fourth class, is necessary. This will mean the logging over a larger area to get the necessary amount of lumber of a quality that will produce veneer, but will leave the land in much better shape. Land which is so far from the mill and which cannot be lumbered profitably in this conservative manner, should not be lumbered at all, for the present rise in stumpage prices is probably making the land earn a bigger income than it could earn if stripped without any provision made for reproduction.

It seems very evident from all indications that there will be a shortage of other soft woods in this locality. In view of this fact the planting of white pine on the old worn out pastures of the locality is a very important part of forestry work which should be carried on here.

9. Land owned by Mr. Slade.

Town—Stowe. Date of inspection Sept. 1913.
Area—200 to 300 acres.

Type description.—Most of this land is pastured with sheep and cattle. About ten years ago the spruce was cut down to a diameter of 10 inches. The remaining stand is old growth hardwoods consisting of yellow birch, maple and beech. The owner now has an opportunity of selling the large birch which are very scattered, and was advised to do so. The open land is rapidly seeding into spruce, and it was recommended that the unseeded openings be planted with Norway spruce. Spruce is here preferable to pine because of the elevation, about 1,800 feet.

10. Land owned by Mr. Whitney.

Town—Springfield. Date of inspection Sept. 1913.
Area—15 acres.

Type description.—Stand of mature hemlock. Recommended that this be cut clean, as the trees are through growing, and that the land be planted with white pine.

11. Land owned by Mr. Beal.

Town—Springfield. Date of inspection Sept. 1913.
Area—120 acres.

Type description.—Mixture of old hardwoods, with a scattering of large hemlock. Recommended that the owner have this lot marked as there is considerable vigorous second growth of different species which should be saved, and there is danger of creating too large openings by indiscriminate cutting. The main drawback to the practice of forestry in this region, is the lack of profitable market, there being no mill which buys logs, within easy hauling distance. There are several portable mills whose owners buy lots for a lump sum and cut them off. If the owners of Lots 3, 4, and 5, can get one of these mills to locate in a central position and sell their logs by the thousand feet, there will be an excellent opportunity of carrying out the recommendations made above.

12. Land owned by Miss Ellis.

Town—Springfield. Date of inspection Sept. 1913.
Area—26 acres.

Type description.—Eight acres is an old sugar orchard, from which most of the old trees had been removed, so that there remain but about 50 to 75 trees large enough to be tapped. There is a heavy maple reproduction from 3 to 20 feet high, overtopped by scattered white birch, pignut hickory, basswood, ash, beech, and a few big hemlock. Recommended that a removal cutting be made in order to develop a young sugar orchard. All of the old trees were marked for cutting, which could be spared without creating too large openings. Maple, and the best ash and basswood, were left for shade and seed. It is thought that this cutting will release the young maple already started, which, if thinned properly from time to time, will produce a healthy young sugar orchard. Remaining 18 acres was old growth hardwood and hemlocks, with clear cut area which had seeded into hardwoods. Recommended that a selection cutting be made, removing most of the large mature birch, hemlock, beech and maple, but that the large chestnuts be held a few years for better marketing facilities.

13. Land owned by Prescott Evarts.

Town—Windsor. Date of inspection Sept. 11, 1913.

Type description.—This is in the village of Windsor, and is used as a park. It is chiefly white pine with some clumps of hardwoods. Many of the large pines are overmature, and from a commercial standpoint should be cut, but on account of esthetic reasons it was recommended that only diseased and dying trees be removed. In some places white birch is to be favored for the same reasons.

14. Land owned by Col. H. S. Foster.

Town—Calais. Date of inspection Sept. 12, 1913.
Area—50 acres.

Type description.—This is the remains of a virgin stand on steep slope east of pond. Mixture of hardwoods such as sugar maple, white and yellow birch, beech and large hemlocks 2′ to 3′ in diameter and occasional spruce 6″—18″. On the edges there are patches of second growth spruce 3″—8″. Much of the old growth is defective and should be cut. This land has been in the Foster family since the farm was cleared—over one hundred years. The forest has always been handled conservatively, with result that old age classes are over represented. Owing to the wishes of the owner, only a very light selection cutting was marked for. Some of the larger hemlocks and defective hardwoods were marked for removal.

15. Land owned by Austine Institute.

Town—Brattleboro. Date of inspection Oct. 9, 1913.
Area—50 acres.

Type description.—Mixture of chestnut, hemlock, soft maple and other species. The inspection was asked to determine whether the chestnut was affected by the chestnut blight parasite (Eudothia parasitica) which had been found in southern Vermont. Inspection showed that the disease was very prevalent on clumps of young chestnuts, having already killed many specimens. In an older woodlot no sign of the disease was at first found, but on climbing some trees it was evident that the tops of many were infected. Recommended that all chestnut trees be removed from the land; also soft maple because of their inferior quality, and that the land be fenced off, and replanted with white pine. The tops of the trees cut should be piled and burned while there is a light covering of snow on the ground.

16. Land owned by Ira Rich Kent.

Town—Calais. Date of inspection Oct. 16-17, 1913.
Area—100 acres.

Type description.—Two woodlots in farm just north of Kents Corners. One is much abused sugar orchard of about 20 acres. There are probably not over 50 sugar trees per acre, if as many. Along west edge good reproduction of spruce, hemlock and fir has come in under hardwoods. Pasturing has prevented maple reproduction. The other lot is in equally bad shape. Wood for fuel has been cut clean from mixed hardwoods. On a slope which was marked there was a scattered stand of old hemlock 2′ to 3′ in diameter with white ash, yellow birch, butternut, etc. Down on the lower edge there is some good fir reproduction, but pasturing has prevented it in most places. There are a great many dead and down trees. Recommended—that the sugar orchard be fenced. The lot was marked for a light selection cutting, leaving many defective maples for sugar purposes which would otherwise be cut. In the other lot most of the mature hemlock, also large basswood, ash, birch, and maple were marked. In the upper part this is a preparatory cutting; and in the lower part a final cutting of the shelterwood system. It is further recommended that the openings be planted with white pine, since it was impossible to leave enough seed trees to secure good natural reproduction.

17. Land owned by Mr. Davis.

Town—Essex. Date of inspection Oct. 18, 1913.
Area—60 acres.

Type description.—About one-third is second growth pine; white and pitch 5″—15″ in diameter. A few acres would cut 40,000 hard board feet per acre, and make a very interesting stand. About one-third is gray birch 2″—4″ of very little value, with one patch of a few acres of mixed hardwoods; soft maple and white birch 5″—8″. About one-third is very sandy open land, which should be planted with pine. Most of this has been pastured. Old pine stumps show original pine growth trees 4′—5′ in diameter. Recommended—Improvement thining in pine, favoring white, by removal of patch, etc., and a clean cutting of gray birch followed by planting white pine; also planting in the open land.

18. Land owned by Walter Dodd..
Town—Corinth. Date of inspection Oct. 21-23, 1913.
Area—100 acres.

Type description.—This is part of an old virgin forest which has been somewhat culled from time to time. On the ridges there is a good deal of old hemlock 2′ to 3′ in diameter. Several have died recently. Portions evidently burned over 50 years or more ago came up to white birch and poplar. On lower, moister slopes, there is considerable mixture of second growth fir, hemlock and spruce and yellow birch. Under this are clumps of splendid fir reproduction. In the openings made 15—20 years ago there are pure stands of fir 3″—5″ in diameter. The lot was marked for a combination of selection and group systems and improvement thinning. Where splendid fir reproduction was started the group system was used, removing all the over-story including some good growing fir. In pure stands of fir 5″ to 10″ an improvement thinning was made to get better growth. In old hemlock stands on the ridges a selection cutting was made with the hope of getting a mixture of fir, spruce and hemlock.

19. Land owned by Miss Proctor.
Town—Proctor. Date of inspection Oct. 29, 1913.
Area—200 acres.

Type description.—Inspection was requested for open land on top of ridge east of Proctor village—elevation about 1,000 feet. About 50 acres is too steep and high for profitable pasture. In places the soil slipped badly during the past spring. Also on top of the ridge and on the east slope there is some cut-over hardwood land in bad shape. There are also two stands of mixed white birch and other species; one high up and one low down; and near the road about 20 acres of splendid mixed harwoods 20-25 years old; white ash, pignut hickory, sugar maple, butternut, beech, ironwood, etc. Recommended—that the 50 acres of open land be planted, about half in 1914 and half in 1915. In 1914 plant 2,000 white ash in depression on east slope; about 10,000 white pine, either 3 or 4 years; 4,000 Scotch and 4,000 Norway pines. In places where land is slipping stakes should be driven in about 2′ apart in rows 3′ apart and brush piled against them to hold the soil until the trees become well rooted. The good hardwoods should be marked for a thinning, favoring ash and hickory. In mixtures of white birch the beech, ironwood and defective birch should be removed.

20. Land owned by Mr. Porter.
Town—Sharon. Date of inspection Nov. 5, 1913.
Area—500 acres.

Type description.—50 acres open field and pasture; 20 acres old field white pine; 230 acres mixed hardwoods; 200 acres birch and poplar. The mixed hardwoods are all aged stands with a large mixture of ash,basswood and red oak. The birch is largely mature but with some young stands, and the poplar is all mature. The open land has been cultivated. Timberland has been stripped of all mature pine, but very little hardwood has been cut. Recommended—Planting of open lands to white pine, except in one place where the weevil was bad, where Scotch pine should be used. Advised thinning of mixed hardwoods stands, cutting birch and poplar, reproducing ash and basswood where possible; saving part of white birch stand in other places and clear cutting and planting in still others.

21. Land owned by T. D. Hobart of Texas.

Town—Berlin. Date of inspection Nov. 6, 1913.
Area—20 acres of plantations.

Type description.—These plantations have been made in 1910, '11, '12 and '13. White pine has been planted on the driest ledges of the farm—old pasture land. Planting was carefully done and over 90% of the trees are alive, in places 95%.

In several small depressions the tops of pines had been killed back by frost of early September '13. Five feet higher up they were undamaged. Norway spruce has been planted on moister land and is doing well, very few having died. Recommended refilling vacancies in pine with 2,000 4-year white pine @ $6.75; planting 4 acres on east of ledge with 5,000 3-year white pine @ $5; and finishing spruce piece with 3,000 Norway spruce @ $5.50.

22. Land owned by City of Montpelier.

Town—Berlin. Date of inspection Nov. 6, 1913.
Area—40 acres of plantations.

Type description—Plantations of white and Scotch pines set in the spring of 1913 were inspected. Below the road Scotch pine was planted in strong grass growth which was choked out some of the seedlings. About 70% are alive. Above the road white pine planted on pasture has done better (about 80% alive). Recommended that about 5,000 4 year white pines and 5,000 3 year Scotch pines be planted in the failed places, and that on new land 20,000 3 year Scotch pines, and 20,000 3 year white pines be used. In future plantings in strong grass, furrows should be plowed 6′ apart and trees set in the furrows. This method has been used by the Hartford Water Board in Connecticut in planting strong grass land.

23. Land owned by E. T. Merritt.

Town—Springfield. Date of inspection Nov. 7, 1913.
Area—200 acres.

Type description.—(1) Two rocky fields which hardly paid to cultivate. (2) A runout pasture consisting of open land, sugar orchard, mature hemlock, young sapling hardwood stand with good mixture of ash and basswood, older second growth hardwoods out of which best ash had been cut. (3) A stand of mature poplar with scattering second growth spruce. Some attempt has been made to cultivate the fields. The pasture has been heavily stocked but summer silo has been necessary. Some of the hardwoods have been cut clean and sold in Springfield at $9 to $10 per cord. All the mature ash and black cherry have been cut. Recommended—Using fields as intensive pasture, and excluding the stock from the old pasture. The mature hemlock should be cut and this land, together with the open land in pasture, should be planted with white pine. Thinnings and reproduction cuttings should be made in the hardwood stand, favoring ash, basswood, yellow birch, black cherry and hard maple in the above order. The poplar stand should be cut, favoring spruce reproduction.

24. Land owned by Mr. Cutler.

Town—Springfield. Date of inspection Nov. 7, 1913.
Area—50 acres.

Type description.—Mixed hemlock, spruce, hardwoods, and poor pasture, which has been lumbered over by hit or miss methods, taking out only what was needed for some special purpose at the time. Recommended—Cutting of hemlock, some spruce, and some hardwoods, and allowing the area to seed up to white pine and other species where possible. Solving pasture problem by some other method, and planting everything which could not be reproduced naturally, as the land can be more profitably used for forest than pasture.

25. Land owned by F. S. Howe.

Town—Springfield. Date of inspection Nov. 8, 1913.
Area—100 acres.

Type description.—Rich swamp which can be made into the best of agricultural land by cleaning and draining, and an open rocky upland pasture. Another lot of second growth hardwood of various ages. Swamp has been cut nearly clean and has come into grass between the few up-rooted trees left. The mature timber has been cut in the hardwood type. The 50 acres of pasture has been rented at $25.00 per year, or about 50c an acre. Recommended—Planting pasture land to white pine, thinning in hardwood, and securing advice of County Agricultural Agent as to using the swamp for farm purposes.

26. Land owned by I. R. Kent and Mr. Howard.

Town—Hardwick. Date of inspection Nov. 12, 1913.
Area—1,000 acres known as Jeudevine Lot.

Type description.—About 100 acres north of road is an old pasture partly grown up with spruce 4″—8″. About 50 acres still open with the exception of occasional trees. South of road there are 6 or 8 acres of old mowing. The main area is a badly cut-over tract on north slope facing Craftsbury Road, varying in elevation by about 800 feet. Everything was cut down to 6″ with exception of two ravines, practically all of the softwoods and best hardwoods. After 6 years, cutting operations fire swept over about one-third of the area in 1908. This part is today like much of east slope of Camel's Hump. The remainder has a stand of 10—15 cords of hardwood to the acre, part of which would make lumber. A few small areas of second growth hardwoods 5″—8″ escaped fire. Recommended—50 acres on north of road and 6 on south should be planted with 1,000 3 year white pines per acre. Burned areas where free from brush may later be planted. The old hardwoods should be cut clean and the land planted with pine. Later a thinning should be made in second growth hardwoods.

27. Land owned by F. M. Childs.

Town—Marlboro. Date of inspection Nov. 13-14, '13.
Area—80 acres.

Type description.—(1)—Second growth spruce all ages, including quite a few of old field form. Most of the type was fully stocked. (2)—Spruce and balsam swamp. (3)—Open pasture land, slightly grazed. Small areas clear cut. Many trees infected with the disease of witches broom. Recommended—Reproduction cutting where large percentage of bull spruce, mature trees, red rot spruce, or fir, with witches broom, making small openings which will reproduce to spruce. The poor pasture should be planted and the swamp left as at present, since it will be better for agriculture than for forestry when it can be drained.

28. Land owned by Walter Pratt.

Town—Brattleboro. Date of inspection Nov. 17, 1913.
Area—75 acres in two lots.

Type description.—Back lot mixed hardwoods of inferior species. Hemlock on the upper slopes, with a scattering growth of chestnut on the east slope. The home woodlot is a mixed stand of old growth hardwoods with some hemlock and a very little pine. The back woodlot was heavily cut some 40 years ago, but has not been touched since. The home woodlot has been thinned by taking out the timber on the farm as needed. Recommended—On back woodlot a clear cutting and planting, since natural reproduction of any desirable species is impossible. In the woodlot a selection cutting should be made.

29. Land owned by John Barney.

Town—West Brattleboro. Date of inspection Nov. 17, 1913.
Area—50 acres.

Type description.—Second growth pine even aged—ranging in age from stands which are open and mature to very young stands which have just reached the point where they ought to be thinned. The old pasture grown up to pine. Recommended—Cutting the mature stand in the smaller area and thinning the younger stands as soon as a market can be found for the material to be removed.

30. Land owned by E. B. Cobbett.

Town—West Brattleboro. Date of inspection Nov. 17, '13.
Area—25 acres.

Type description.—Mixed hardwood growth and sugar maple. The former owner has pastured the orchard, and has paid no attention to cutting out the diseased trees, and has too many trees for orchard purposes. Mature growth in the mixed hardwood stand has been pretty well cut out. Recommended—Planting pasture to white pine and a selection cutting in hardwood stand, favoring ash, basswood, oak and yellow birch, and removing the smaller suppressed and diseased trees in the maple orchard, and a few of the larger trees affected by the maple borer.

31. Land owned by H. E. Bartram.

Town—Brandon. Date of inspection Nov. 26, 1913.
Area—100 acres.

Type description.—(1)—Old field white pine of all ages with large percentage of individuals having "bull" form, and a small area of thick pine and area of second growth pine of good form. (2)—Mixed hardwood stand of very open character, and with scattering mature oak and small area of old mature poplar, and about one-third of a stand of softwood seedings underneath the open hardwoods, and well distributed over the whole area. (3)—Small knoll of about 20 acres of open pasture land. This was used for a sheep pasture until the area became so small and the cost of keeping fences so great, that it was discontinued. Recommended—Open land should be planted to white pine. The white pine stand should be thinned in places and the openings made for reproduction in the more mature parts, or where there is a large percentage of bull pine. The oak and poplar should be cut at once, and the hardwoods clear cut, and the area planted to pine as fast as convenient.

32. Land owned by Vermont Box Company.

Town—Buels Gore. Date of inspection Dec. 4, 1913.
Area.—2,000 acres.

Type description.—This tract is on the main Green Mountain range, about 10 miles south of Camel's Hump; about 2 miles east of Hanksville; bounded on the north by Bartlett's holdings and on south by Champlain Realty Company. Tract was culled of spruce several years ago, but there are a great many scattered patches of spruce, and hardwoods. Recommended—Plan to cut over this tract in about 10 years, having the best portions marked for spruce reproduction.

In the lower portions some of the best soil should be cut clean and replanted with either pine or spruce. With the exception of basswood and poplar, used at the box factory at Bristol, all other lumber is shipped from Jonesville. Elevation probably varies from 1,500 to 3,000 feet.

33. Land owned by Bristol Manufacturing Company.

Town—Bristol. Date of inspection Dec. 5, 1913.

Area—300 acres.

Type description.—Second growth mixed hardwoods 50—60 years old. Yellow birch, poplar, white ash, maple, etc. Type covers east slope and top of a high hill about 1 mile south of the village. Elevations vary by nearly 1,000 feet. About 25 acres on top of the ridge were cut clean in the winter 1912-13. Recommended—As soon as wood already cut is removed, plant with pine. After that, cut clean and plant annually about 27 acres a year, starting at the foot of the hill and cutting mature lots. In cutting leave a few of the best white ash and yellow birch. This plan fits in with the needs of the Company for a permanent supply of pine, as outlined below. The Company requires annually 800,000 feet of pine in addition to other lumber.

COST TO RAISE 800,000 FEET OF PINE A YEAR.

It is safe to count on 30,000 feet of pine box boards to the acre in 40 years.

To cut 800,000 feet 27 acres must be cut over each year.

In order to cut 27 acres a year for 40 years a total area of 1,080 acres is required, or say 1,100 acres.

Cost of 1,100 acres of land at $3		$ 3,300
Cost of planting 1,100 acres of land at $10		11,000
Cost of planting with 4% interest 40 years		$ 52,800
Value of land with 4% interest 40 years		12,540
Tax of 1% on land at 4% for 40 years		3,135
10% yield tax on stumpage at $15		49,500
Total cost of producing 33,000,000 feet		$117,975
Average cost per M		$ 3.58
33 million feet at $15.00	$495,000	
33 million feet at 3.58	117,975	
Total saving in 40 years by planting	$377,025	

34. Land owned by D. W. Eddy.

Town—Monkton. Date of inspection Dec. 10, 1913.

Area—20 acres.

Type description.—This area is of particular interest. It is about 4 acres of pure white pine about 50 years old in splendid condition. The present stand contains about 320 trees per acre. Near this are some scraggly hardwood stands, and below is a stand of white pine 60—70 years old with exceptionally fine reproduction which the owner is cutting clean. At some distance to the south is a small clump of basswood which has been thinned too much by removing all other species. The owner has very successfully thinned the 4 acre piece twice. About 8 years ago he cut 50 cords of wood which just paid for cutting. Later he took out some logs. In places the thinning have been followed by splendid reproduction. The older piece he had also thinned, but it was too old to respond so he decided it was best to cut clean. The reproduction, however, is largely due to this thinning. It would have been better to have left 30 to 40 healthy pines per acre for future growth at this time. On the four acre piece about one-fifth of the trees were marked, perhaps 6,000 feet per acre with the idea of another thinning in about 6 years. Logs are cut and skidded for 5c a piece and hauled to a mill about 1 mile off. Altogether the owner obtains a profit of $12 per M. This has been the best managed lot of pine inspected by the Forestry Department.

35. Land owned by Mrs. Seager.

Town—Brandon. Date of inspection Dec. 11 and 12, 1913.
Area—15 acres.

Type description.—Area has two types of topography; about 6 acres on flat, formerly farm land, is covered with a pure stand of pine about 40 years old. Diameters 4″—12″. This has not been thinned, and about 25% of the trees are dead. Many good Norway pine which invariably run larger in diameter and height than white pine. The other part of about 9 acres is on a ledge about 200 feet high. Scattered white pine 8″—20″ in diameter. Some white birch, poplar, white oak, hemlock, and other species. The piece on the flat was marked for an improvement thinning. All dead and about 25% of the live trees were marked; most small trees. On the ledge a combination of selection cutting and thinning was used. Many scraggly, large topped pines, hemlocks, etc., were marked. Logs will run from 6″—15″ bringing up the quality of the whole.

36. Land owned by Fred Curtis.

Town—Westfield. Date of inspection Dec. 17, 1913.
Area.—50 acres.

Type description.—Second growth spruce 8″ to 15″ with mixture of fir, hemlock, soft maple and other hardwoods. A few large pine and some reproduction of pine with spruce and fir. The owner has cut clean in places for winter's wood supply. Recommended—Combination of thinning and selection cutting. Remove many soft maples which are damaging thrifty young fir and spruce. Also cut mature hemlock and some of slender spruce leaving the best ones for more growth and reseeding. Pine and fir reproduction is growing very rapidly, and with proper handling, the value of the lot can be doubled in ten years.

37. Land owned by George M. Calkins.

Town—Charleston. Date of inspection Dec. 19, 1913.
Area—25 acres.

Type description.—Very good stand of old growth spruce, some trees containing 800 to 1,000 feet; also hemlock, yellow birch, white ash, basswood and fir. Parts of this stand would cut 10,000 to 15,000 feet per acre. A good many of the spruce have red rot, and some have broken off. Land is level and easily logged. Present owner is cutting off without regard to reproduction to get 70,000 feet to build a barn. His spruce butt logs will be sold in Barton for sounding boards @ $22 per M. The haul is about 12 miles. Recommended—In order to get spruce and fir reproduction, most of the hemlock and part of hardwoods should be cut, leaving enough large topped spruce and fir supported by hardwoods to reseed. Fir reproduction will be particularly easy to secure.

38. Land owned by S. E. Gray.
Town—Morgan. Date of inspection Dec. 19, 1913.
Area—50 acres.

Type description.—This tract is just west and a little above Seymour Lake. Part of it is low and rather wet, with a mixture of cedar and fir with some brown ash, yellow birch, spruce and other species. Cedars are fairly sound and run 1′ to 2′ in diameter. Many are uprooted. The firs are 5″ to 15″ and are very tall and slender. South of this is a pasture grown up to fir 80%, and spruce 20%—ages 1—30 years, and adjoining this is an area which came up still earlier and has a good stand of the same species 30 to 50 years. Recommended—Since fir grows more than twice as fast as cedar, the percentage of fir should be increased, i. e. a selection cutting of larger cedars should be made, leaving enough firs to seed up, and enough hardwoods to hold up the firs. Advised cleaning up "down stuff" and the largest cedar first; then going over the land again more intensively. In the mature fir stand the strip system should be used to get reproduction of fir.

39. Land owned by Windsor Cemetery Association.
Town—Windsor.
Area—20 acres.

The tract is made up of a stand of hemlock, old culled hardwood, second growth hardwood, and a sapling hardwood stand. The hemlock was marked for a selection cutting, and the older culled hardwood for clear cutting. It was recommended that the second growth hardwood be cut clean within a few years, and the sapling hardwoods thinned as soon as market conditions would permit. Planting of pine was recommended in the hemlock stand where large openings were made, in the culled hardwood where reproduction had not already taken place, and where the second growth hardwood was removed.

40. Land owned by C. F. Carpenter.
Town—Richford. Date of inspection Jan. 29, 1914.
Area—About 20 acres.

Type description.—Cut-over spruce and pine naturally coming up to fir and pine reproduction. There is a slight mixture of hardwoods and a few old growth hemlocks. This was lumbered with no regard to reproduction whatever, but accidental reproduction has fairly well restocked the area with a stand which is now all sizes from seedlings to 30 foot poles. Recommended.—Cleaning out the hardwoods which interfere with softwood growth as fast as needed for stove or cordwood; also cutting the hemlocks to the smallest merchantable diameter as fast as needed for building purposes on the premises. A few openings in the hardwoods should be made where softwood reproduction can be secured. In one or two small areas a thinning was advised in connection with the above mentioned operations.

41. Land owned by Clark & Gray.
Town—Dorset. Date of inspection Mar. 14, 1914.
Area—250 acres.

Type description.—Cut-over hardwood land, half of which is practically barren. Two-thirds of the remaining area is coming up to sapling hardwoods, and the rest to a mixture of spruce and hemlock. The lots will make very open, poor quality lumber. There is also a 12 acre open field. There will be nothing to cut for several years, and only a small area can be advantageously planted at present.

42. Land owned by G. M. Hazard.

Town—Monkton. Date of inspection Mar. 25, 1914.
Area—120 acres.

Type description.—Second growth pasture pine with a mixture of hardwoods in some localities. When the old pine stands were cut off enough was left so that a very uneven growth came in. Recommended—A thining in younger stands; cutting trees financially mature so as to reproduce white pine, and removing hardwoods so as to favor pine where possible. Also recommended keeping stock out of the whole woodlot including the sugar orchard.

43. Land owned by A. B. Miles.

Town—Monkton. Date of inspection April 6, 1914.
Area—50 acres, scattered areas 1 to 20 acres in size.

Type description.—White pine, mostly second growth, with a little old growth on a ledge. Some red pine on the upper side on a burnt area. Recommended—That the old growth be cut after the next seed year as the land is already fairly well reproduced. Stands where "bull" pine are present should be thinned, leaving smaller but straighter trees.

FOREST PLANTING.

The planting season of 1914 was about three weeks later than in the previous year. No trees were shipped until the middle of April. However, the season was favorable for planting, as warm weather held off and it did not become dry until well into May, when the plantations had become well established.

The supply of white pine was just about equal to the demand, practically all of the three and four year trees being disposed of. Of Norway spruce raised, there was a slight surplus carried over for the fourth year.

Plantations started in previous years were enlarged, thus demonstrating the success former plantings have made. Among these may be especially mentioned the plantation made for Sally Fisher, a little girl of four years, in the town of Arlington. 37,000 trees have been planted here, which should be worth, by the time the owner is forty-four years old, about $6,000. The Lyndon School of Agriculture has continued its demonstration plantation, by setting 2,000 white and 4,000 Scotch pine. On the dry sandy soils about Lyndon the Scotch pine has shown a splendid growth. Dr. Wm. S. Stevens has continued his extensive planting in Enosburg, having set out altogether during the past five seasons, 213,000 trees. The Norway spruce plantation made by Dr. Stevens three years ago, is one of the most successful in the State. The white pines have done well, with the exception of those set in 1911, which was the most unfavorable season since the establishment of the State nursery. In the town of Braintree, Mr. Geo. W. Flagg has planted in the past four years 15,500 trees. Mr. Eugene Fellows in Orange, and Mr. Dix Camp and Mr. A. A. Priest in Randolph, and Miss Vaughan in Thetford, continued plantings previously begun. Mr. G. S. Swan, representative from Tunbridge, planted 1,000 trees in 1913 and 9,000 in 1914. Mr. T. D. Hobart, and the Montpelier Water Commission, enlarged their extensive plantations in Berlin. Others in Washington County, who have previously planted, are the C. C. Putnam & Son Lumber Company in Middlesex; the Jones Lumber Company in Warren, and Hon. O. L. Martin in Plainfield. Several of those who planted in Windham and Windsor Counties had made previous plantations, e. g. the Estey Organ Company, Mr. Chas. W. Richardson, Mr. O. L. French, and Mr. E. B. Barrows, Jr., of Brattleboro; the Bellows Falls Water Department, Mr. D. P. Wright of Westminster, the Bridgewater Woolen Company, Master Harold Sawyer of Plymouth; Mr. A. B. Finney, Mr. B. H. Lamb, Mr. J. J. Parker, and Mr. Chas. Noyes in Sharon; Mr. A. B. Morgan, Mr. A. L. Powers and Mr. Edgar H. Williams of Woodstock.

The most extensive planting of the year was that of the Fairbanks Scale Company, which set 100,000 white pines on its land in St. Johnsbury. Others who started new plantations of considerable size include: Mr. Ira R. Kent on his lands in Hardwick and Calais; Mr. H. G. Shaw in Underhill; the City of Barre on its watershed in Orange; Dr. H. F. Walker in Chittenden; Miss Emily D. Proctor in Proctor; Mr. J. M. Johnston, Jr. in Brattleboro; Mr. Lee S. Haven in Londonderry; Mr. W. A. Blodgett in Royalton; Mr. H. C. Porter in Sharon; the Village of Springfield on its watershed; Mr. Geo. Waite in West Windsor; Mr. Geo. C. McCausland in Woodstock.

LIST OF TREES SOLD BY THE STATE NURSERY 1914.

ADDISON COUNTY.

Cornwall	J. E. Sperry	1,000	3 year Norway Spruce
Lincoln	E. S. Stearns	5,000	3 year white pine
Middlebury	C. L. Witherell	1,000	3 year Norway Spruce
Monkton	D. W. Eddy	3,000	3 year white pine
Shoreham	F. E. Douglas	1,000	3 year white pine
		11,000	

BENNINGTON COUNTY.

Arlington	John R. Fisher	12,000	3 year white pine
	H. A. Hulet	1,000	3 year white pine
Dorset	Mrs. Anna E. Gilbert	200	3 year white pine
Manchester	Lester Farnum	1,000	3 year white pine
	H. B. Kendall	1,000	3 year white pine
	James D. Purdy	1,000	3 year white pine
		16,200	

CALEDONIA COUNTY.

Barnet	A. D. Warden	1,000	3 year white pine
	H. J. Warden	1,000	3 year white pine
Danville	V. E. Lurchin	5,000	3 year white pine
Groton	Peter M. Abbott	1,000	3 year white pine
	H. R. Page	2,000	3 year white pine
	C. A. Ricker	2,000	3 year white pine
	A. G. Sawyer	2,000	3 year white pine
	Dr. H. L. Tillotson	1,000	3 year Scotch pine
Hardwick	Ira R. Kent	10,000	3 year white pine
Lyndon	Lyndon School of Agr.	2,000	3 year white pine
		4,000	3 year Scotch pine
	Mrs. Jennie Michaud	2,000	3 year white pine
	G. T. Ruggles	1,000	3 year white pine
		1,000	3 year red pine
Peacham	R. B. Kinerson	1,000	3 year white pine
St. Johnsbury	Fairbanks Scale Co.	100,000	3 year white pine
	Marcus Hovey	5,000	3 year white pine
	Chas. A. Joyce	5,000	3 year white pine
	W. C. McCrae	3,000	3 year white pine
	J. B. Stanton	3,000	3 year white pine
Waterford	L. E. Johnson	3,000	3 year white pine
		155,000	

CHITTENDEN COUNTY.

Hinesburg	F. W. Perry	1,000	3 year white pine
Milton	Hon. D. T. Hanley	500	3 year white pine
Underhill	H. G. Shaw	4,000	3 year white pine
		1,000	3 year red pine
		1,000	3 year Norway spruce
		7,500	

ESSEX COUNTY.

Brighton	G. R. Petrie	1,000	3 year Norway Spruce
Canaan	W. B. Cook	1,000	3 year Norway Spruce
		2,000.	

FRANKLIN COUNTY.

Enosburg	Dr. Wm. S. Stevens	32,000	3 year white pine
		12,000	3 year red pine
		8,000	3 year Norway Spruce

St. Albans	Hon. E. S. Brigham	500	4 year white pine
	G. C. Lee	100	4 year white pine
Swanton	P. J. Farrell	500	3 year white pine
		53,100	

ORANGE COUNTY.

Braintree	Geo. W. Flagg	5,000	3 year white pine
		200	3 year Norway Spruce
Chelsea	Chas. E. Dickinson	2,000	3 year white pine
	L. A. Farrington	1,000	3 year white pine
	R. H. Stanton	1,000	3 year white pine
Fairlee	J. C. Miller	500	3 year white pine
	G. L. Robinson	1,000	3 year white pine
Newbury	J. W. Eastman	1,000	3 year Scotch pine
Orange	City of Barre	10,000	3 year Norway Spruce
	Eugene R. Fellows	2,000	3 year white pine
		2,000	2 year white pine
		2,000	3 year Scotch pine
Randolph	Dix J. Camp	5,000	3 year white pine
	E. F. Kibby	2,000	3 year white pine
	W. H. Perham	1,000	3 year white pine
	A. A. Priest	4,000	3 year Scotch pine
Thetford	C. C. Cook	250	3 year Scotch pine
	Miss C. Vaughan	2,000	3 year white pine
Topsham	J. E. Eastman, Jr.	2,000	3 year Scotch pine
	Ernest S. Locke	500	4 year white pine
		500	3 year Scotch pine
Tunbridge	Mrs. Marion Burnham	1,000	3 year white pine
	Frank J. Hayt	1,000	3 year white pine
	G. S. Swan	9,000	3 year white pine
Vershire	W. H. Orr	1,000	3 year white pine
West Fairlee	Harris M. Miller	1,000	3 year white pine
		57,950	

ORLEANS COUNTY.

Craftsbury	S. R. Lathe	500	3 year white pine
		500	

RUTLAND COUNTY.

Chittenden	Dr. H. F. Walker	7,000	3 year Norway Spruce
Clarendon	E. M. Eddy	2,000	2 year white pine
Pittsford	Vermont Sanatorium	5,000	3 year white pine
Proctor	Miss Emily D. Proctor	10,000	4 year white pine
		4,000	3 year Scotch pine
		4,000	3 year red pine
		2,000	2 year white ash
		34,000	

WASHINGTON COUNTY.

Barre	D. A. Perry	2,500	3 year white pine
	F. H. Rogers	1,000	2 year white pine
Berlin	T. D. Hobart	7,000	3 year white pine
		1,900	3 year Norway Spruce
		200	2 year white ash
		500	3 year red pine
	Montpelier Water Dept.	20,000	3 year white pine
		7,150	3 year Scotch pine
Calais	Walter J. Coates	1,000	3 year white pine
	Ira R. Kent	1,000	3 year white pine
Duxbury	Philip Shonio	1,000	3 year white pine
Middlesex	Ralph W. Putnam	13,000	3 year white pine
Plainfield	H. P. Hinman	5,000	3 year white pine
	Hon. O. L. Martin	5,000	3 year white pine
Waitsfield	W. H. Moriarty	3,000	3 year white pine
		2,000	3 year Norway Spruce
	Richardson Bros.	4,900	3 year white pine
Warren	Jones Lumber Co.	10,000	3 year Norway Spruce
Worcester	Elisha Fiske	2,000	3 year white pine
		1,000	3 year Norway Spruce
		89,150	

WINDHAM COUNTY.

Brattleboro	E. B. Barrows, Jr.	2,000	4 year white pine
	H. R. Brown	3,000	3 year white pine
		2,000	3 year red pine
	Estey Organ Company	1,000	3 year white pine
	O. L. French	1,500	3 year Scotch pine
		500	3 year Norway Spruce
	J. M. Johnston, Jr.	1,000	4 year white pine
		5,000	3 year white pine
		1,000	3 year Scotch pine
	Chas. W. Richardson	2,000	3 year white pine
		500	2 year white ash
		500	1 year black locust
Grafton	C. W. Fairbanks	1,000	2 year white pine
	Francis A. Palmer	1,000	2 year white pine
Jamaica	W. G. Adams	4,000	3 year white pine
Londonderry	F. F. Churchill	2,000	3 year white pine
	Lee S. Haven	10,000	3 year white pine
Newfane	A. M. Merrifield	6,500	3 year white pine
Rockingham	Bellows Falls Water Dept.	3,000	4 year white pine
		10,000	2 year white pine
		2,000	3 year Norway Spruce
Townshend	F. H. Davis	2,000	3 year white pine
Westminster	Chas. E. Howard	1,800	3 year white pine
		200	2 year white ash
	D. P. Wright	1,000	3 year white pine
		64,500	

WINDSOR COUNTY.

Bethel	E. L. Bass	1,000	3 year white pine
	Guy Wilson	200	4 year white pine
		3,200	3 year white pine
Bridgewater	Bridgewater Woolen Co.	25,000	3 year white pine
		5,000	2 year white ash
Cavendish	Miss F. B. Fletcher	1,000	3 year white pine
Chester	Dorand Bros.	1,000	3 year white pine
Hartland	Arthur J. Rogers	2,000	3 year white pine
	F. G. Spear	500	2 year white pine
Ludlow	Jesse H. Spaulding	1,000	3 year white pine
Plymouth	James D. Brown	1,500	3 year white pine
	Harold E. Sawyer	4,000	3 year white pine
Pomfret	E. Y. Dana	2,000	3 year white pine
	Quechee Fells Farm	2,000	3 year white pine
Royalton	W. A. Blodgett	30,000	2 year white pine
	Amos J. Eaton	2,000	3 year white pine
		1,000	3 year Norway Spruce
Sharon	A. B. Finney	1,000	3 year white pine
	B. H. Lamb	1,000	3 year Scotch pine
	Don E. Moore	1,000	3 year white pine
	H. W. Moore	500	3 year white pine
		500	2 year white pine
	E. H. Noyes	4,000	3 year white pine
	J. J. Parker	1,000	3 year white pine
	H. C. Porter	37,000	3 year white pine
	W. H. Robinson	2,500	3 year white pine
	F. W. Welch	3,000	3 year white pine
Springfield	Burnham Bibens	3,500	3 year white pine
	Fred C. Davis	500	3 year white pine
		500	3 year red pine
		1,500	3 year Norway Spruce
	W. E. Leonard	500	3 year white pine
	F. E. Spellman	2,000	4 year white pine
	Springfield Village	10,000	3 year white pine
Weathersfield	C. F. Aldrich	1,000	3 year white pine
West Windsor	Geo. G. Waite	10,000	3 year white pine
Woodstock	E. G. Bailey	100	3 year white pine
	Dr. R. W. Boyce	1,000	3 year white pine
	Mr. Colby	500	3 year white pine
	Henry W. Daniels	2,000	3 year white pine
	E. D. Faulkner	500	3 year white pine
	J. Livingston	1,250	3 year white pine
	Geo. G. McCausland	1,600	4 year white pine
		3,000	3 year white pine
		1,000	2 year white pine
		1,400	3 year Norway Spruce
	Edgar F. McClay	1,000	3 year white pine
		1,000	2 year white ash
	A. B. Morgan	1,000	4 year white pine
		1,000	3 year white pine
	A. L. Powers	1,000	4 year white pine
		16,500	3 year white pine
		1,000	3 year Scotch pine
	Edgar H. Williams	10,000	3 year white pine
		208,250	

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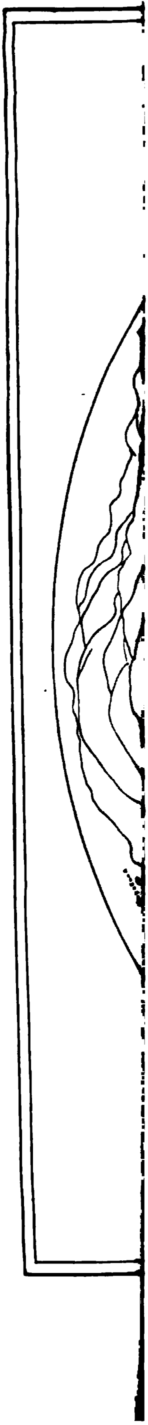


Beth

Brid

Cave
Ches
Hart

Ludl
Plym

Pomf

Roya

Shar

Sprin

Weat
West
Wood

SUMMARY OF TREES PLANTED IN 1913 BY COUNTIES.

Addison County, Private planting	11,000
Bennington County, Private planting	16,200
" " State planting	46,000
Caledonia County, Private planting	155,000
" " State planting	14,000
Chittenden County, Private planting	7,500
Essex County, Private planting	2,000
Franklin County, Private planting	53,100
Orange County, Private planting	57,950
Orleans County, Private planting	500
Rutland County, Private planting	34,000
" " State planting	45,000
Washington County, Private planting	89,150
" " State planting	23,000
Windham County, Private planting	64,500
Windsor County, Private planting	208,250
" " State planting	13,000
Private planting	699,150
State planting	141,500
Total	840,650

REVIEW OF FOREST PLANTING FOR SIX SEASONS—1909 TO 1914 INCLUSIVE.

It is interesting to note the variety of opinion regarding forest planting and its future in Vermont. Not infrequently it is stated that forest planting will never become popular, and that few can be expected to place money in such a long time investment. On the other hand, there are those who feel that every land owner in the State should plant forests, and complain that the State nursery has not reached as many as it should. There are, undoubtedly, still people in Vermont who have not heard of the State nursery, but every effort has been made to popularize forest planting, and the writer feels that the interest has grown as rapidly as could be expected. Each year the first plantations are becoming larger and are arousing more interest, and the demand for nursery stock will undoubtedly increase at a fair rate. Although the early improvement of waste land by planting, and its increased sale value, is appealing to more and more people, one can scarcely expect to interest owners in forest planting until they have reached comfortable circumstances.

That a great deal of money now spent for phonographs, automobiles, and other luxuries, might better be invested in forest planting, goes without saying, but it is, perhaps, beside the mark to stimulate New England thrift. What is needed is not so much more saving as wiser investment. The "Blue Sky Law" should help in this direction, but distant speculation will always appeal to some kinds of people, more than nearby conservative investments. There will always be those in Vermont ready to risk money in some California Eucalyptus concern which could be more safely invested in growing pine in their own towns, where they could watch it.

From the first the people on the east side of the State have shown more interest in forestry than those on the west side. Windsor and Windham Counties have led conspicuously in the matter of planting. For the past six years the number of trees planted in these two Counties are respectively 754,450 and 309,000. As explained in the last report, this greater interest is probably partly due to splendid demonstrations on the Billings Estate in Woodstock, and the more recent plantings on the Chas. Downer State Forest in Sharon.

It must also be partly due to the fact, that "nothing succeeds like success". Men have less hesitation in venturing a few dollars in a proposition if their neighbors are doing the same. Thrifty plantations on the East side of the State are now so numerous that every one interested can personally satisfy himself of the practicability of planting. A great many people throughout Caledonia, Washington and Orange Counties, have planted. While a large number of trees have been planted in Rutland County, the work has been done largely by a few owners. There is still much less interest in Essex, Lamoille, Bennington and Chittenden Counties, than there should be, considering the large areas in those Counties which should be reforested. While Addison and Orleans are splendid agricultural Counties, there are considerable areas in each which should be reforested.

Altogether about three million forest trees have been planting in Vermont during the first six years after the establishment of the Forestry Department. While the chief value of these plantings is educational in directing land owners' attention toward other lines of forestry, and bringing about more extensive planting, it represents a total area of nearly 3,000 acres planted. This in itself seems small compared to the total area in the State which should be planted. If plantations were no more productive than natural forests, the actual results in lumber would be insignificant. But as every one realizes that a cultivated potato patch will produce more than one left to itself, so it must be remembered that a forest plantation is much more productive than a forest which has seeded up of itself. A pine plaontation 40 years old will produce an average of 25,000 feet per acre, and one 50 years old will produce 37,000 feet per acre. The area already planted, therefore, may be expected to yield by 1954 about 75,000,000 feet, or by 1964 about 111,000,000 feet. At $10 per thousand feet, this means a stumpage value of $750,000 and $1,110,000 respectively. Allowing 17,000 feet of lumber as the average load of a freight car, the lumber produced from these plantations would fill a freight train of 4,400 cars. If it were all shipped to New York and Boston it would bring to the railroads in freight rates about $200,000; whereas, if it were all used in Vermont it would have an employment value from the stump to the finished product of from $2,500,000 to $7,000,000 according to its uses.

THE STATE FOREST NURSERY, BURLINGTON.

The spring of 1914 was somewhat backward, so that the transplanting work was not begun until April 20th., or nearly three weeks later than in 1913. In spite of the short season, the shipping and transplanting went on better than ever before, about 1,100,000 trees being transplanted. About thirty-five Italian laborers were employed in this work. The situation of the nursery in Burlington is particularly favorable for a large nursery for several reasons. (1)—Labor is usually obtainable at $1.50 per day, while in other parts of the State it costs from $1.75 to $2.00 a day. (2)—The American Express Company calls at the nursery for the trees to be shipped, thus saving the State all cost of transportation which is incurred elsewhere. (3)—The nursery is supplied with City water, and can, therefore, be watered to an unlimited extent. (4)—The soil is light and admirably adapted for growing pines.

There were sown in the nursery in the spring of 1914, the following:

White Pine—Vermont and New York seed	160 lbs.
Red Pine	7 "

White Cedar	2 "
White Spruce	5 "
	174 "

Inventory of nursery stock on hand July 1, 1914.

(Ages given are for the end of the growing season of 1914).

White pine four year transplants	5,000	
White pine three year transplants	1,050,000	
White pine two year seedlings	1,200,000	
		2,255,000
Scotch pine three year transplants	25,000	
Scotch pine Riga variety—two year seedlings	100,000	
		125,000
Norway pine two year seedings		125,000
European Larch three year transplants		7,000
White Cedar two year seedlings		40,000
Black Locust two year seedlings		10,000
		2,562,000

The prices charged for nursery stock in the spring of 1914, were as follows:

White pine, four year transplants	$6.75 per 1,000
White pine, three year transplants	5.00 per 1,000
White pine, two year seedlings	2.50 per 1,000
Scotch pine, three year transplants	5.00 per 1,000
Norway pine, three year transplants	5.75 per 1,000
Norway spruce, three year transplants	5.50 per 1,000
White ash, two year transplants	8.00 per 1,000

STATE NURSERY ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1913.

Balance on hand January 1, 1913	$ 6.14
Received from sale of nursery stock	2,003.38
	$2,009.52

EXPENDED ON NURSERY.

Labor	$1,622.53
Seed	169.50
Fertilizer	72.47
	$1,864.50
Balance on hand January 1, 1914	$ 145.02

VERMONT STATE FORESTS.

Ten State Forests have been acquired, either by gift or purchase, in as many different sections of the State, and have already been very effective in stimulating an interest in private forestry. While the private owner can, in nearly all cases, make his wood lot more profitable by silvicultural treatment, it is impossible for an outside owner, like the State, to manage a small forest as economically as a large one. Since the aim is to show not only silvicultural practice, but financial results, the Forestry Department aims to increase the area of the smaller forests by further purchase, and in the future will buy only tracts of at least 500 acres, except where some special problems can be dealt with. For the benefit of those having lands which they contemplate offering to the State for sale, it may be well to state that the land will be valued not only for the timber, but for the young growth of valuable species upon the land. So much worthless land is offered for sale that occasion is taken here to announce that no tract will be considered for purchase at any price which has been wholly cut off and severely burned over during the past fifteen years. Where only part of a tract is of this character, it may be considered, if the remainder of the area has a value. The State will, however, accept gifts of land of any character suitable for the practice of forestry, provided the areas are not too small.

The first step in the management of any business should be taking account of stock. So in the management of the State Forests the Forestry Department first estimates the amount of lumber and wood on each forest. This is done by the so-called valuation survey method by which all the trees are measured on parallel strips amounting to from 10 to 20 per cent. of the whole area. The volumes of the trees are then computed from volume tables.

The next step in the systematic management of a forest is to determine the growth which a forest is making, in order that an estimate of future yield may be made. Two kinds of growth are recognized by foresters: (a) Mean annual growth; (b) Periodic annual growth. By mean annual growth is meant the average annual growth throughout the age of the forest. It is obtained by dividing the total volume grown by the age. The periodic annual growth, on the other hand, is the annual growth for a definite period in the life of the forest, usually for the last decade. Since the forest does not grow at the same rate throughout its life, the mean and periodic growth are seldom the same. Growth studies in the field have been made for two forests, but have not yet been computed.

CHARLES DOWNER FOREST.

This forest has been more than doubled in area by a recent gift from Mr. Downer of about 500 acres of land just south of the original area. Much of this land is made up of abandoned farms, and is suitable for reforestation. The value of this forest, as a local demonstration, has been plainly shown by the growing interest in planting on the part of land owners in the neighborhood. Aside from small areas near the buildings, the whole area will eventually be used for forestry purposes. One piece of swamp has been under-drained during the past year, and the orchard has been enlarged by the planting of 50 apple trees.

Lot 31, and some other small areas, were planted in the spring of 1914 with 8,000 Norway spruce, and 5,000 white ash, in alternate rows. A new map of the original forest has been completed, the lots being renumbered. The list of plantations is as follows:

Nos. 2 and 4	White pine planted in 1909.
No. 5	Black locust planted in 1911.
No. 6	Norway spruce planted in 1914.
No. 9	White and Austrian pine planted in 1912 and 1913.
No. 12	Scotch pine and Norway spruce planted in 1912 and 1913.
No. 13	White pine planted in 1911 and 1912.
No. 14	White pine planted in 1913.
No. 15	White and red pine planted in 1911 and 1912.
No. 16	White pine planted in 1913.
No. 17	Scotch and white pine planted in 1911 and 1912.
No. 20	Norway spruce planted in 1910.
No. 21	Norway spruce and white pine planted in 1911 and 1913.
No. 22	White pine planted in 1913.
No. 23	European larch and Norway spruce planted in 1913 and 1914.
No. 24	White ash planted in 1913.
No. 26	White pine and red fir planted in 1911.
No. 27	Scotch pine planted in 1910.

No. 28	Red pine planted in 1911.
No. 29	Red pine planted in 1910.
No. 30	White pine planted in 1910.
No. 31	White ash and Norway spruce planted in 1914.

SUMMARY OF TREES PLANTED 1910 TO 1914 (INCLUSIVE).

Species.	No. planted.
White pine,	56,800
Red pine,	22,700
Scotch pine,	19,000
Austrian pine,	2,400
Norway spruce,	24,000
Colorado blue spruce,	100
Red fir,	5,000
Arborvitae,	1,000
Black locust,	3,000
European larch,	4,000
White ash,	15,000
	153,000

The branch nursery maintained on this forest will be made head-quarters for the growing of spruce, since the soil appears to be well adapted for this tree, though less adapted for pine than that at the Burlington nursery. During the very dry summer of 1913 the reservoir became so low that the new seed beds suffered for lack of water. The transplants, however, did better than in previous years. As is shown in the financial statement, considerable nursery stock was sold from the nursery and furnished to other State Forests.

INVENTORY OF NURSERY JULY 1, 1914.

(Ages given are for the end of the growing season of 1914.)

White pine, three year transplants,	225,000	
White pine, two year seedlings,	500,000	
		725,000
Norway spruce, four year transplants,	8,000	
Norway spruce, three year transplants,	100,000	
Norway spruce, two year seedlings,	600,000	
		708,000

Red spruce, three year transplants,	14,000
White spruce, three year seedlings,	400
Sugar maple, three year transplants,	600
	1,448,000

The following seed was sown in June 1914:

50 lbs. white pine seed from New York.
15 lbs. Norway spruce seed purchased from the International Paper Company.

No estimate of the standing timber on this forest has been possible because the new tract has not been mapped.

The first silvicultural cutting on this forest was made in January 1914. A mixed stand of hardwoods near the house was marked for a reproduction cutting. Although the best price could be obtained for ash lumber, very little ash was marked as it is the aim of the management to secure a natural seeding of ash. In a few years after the ground is reproduced the remaining old trees, including the ash, may be cut. Prices will probably be fully as good, if not better, at that time. It will be noticed that this method of leaving the most valuable trees for seed purposes is just opposite from the usual practice of removing the most valuable trees first. This reversal of custom naturally leads to some criticism on the part of those not conversant with forestry principles.

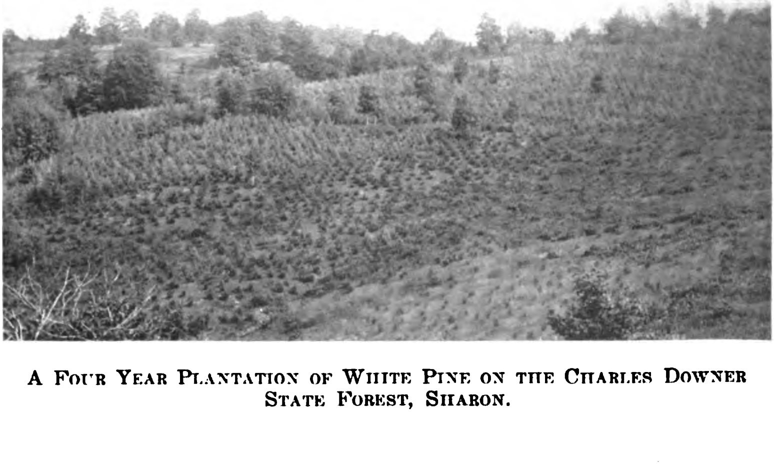
The lumber sold was as follows:

3,544 ft. maple @ $12. per M.,	$42.53
1,149 ft. basswood @ $12. per M.,	13.79
655 ft. butternut @ $12.00 per M.,	7.86
342 ft. elm @ $12. per M.,	4.10
470 ft. ash @ $15. per M.,	7.05
734 ft. beech @ $10. per M.,	7.34
300 ft. birch @ $10. per M.,	3.00
7,194	$85.67

FINANCIAL STATEMENT JULY 1, 1914.

Superintendent's Salary	$ 660.00
Superintendent's Expenses	249.04
Labor	1,264.41
Miscellaneous supplies	334.97
	$2,508.42

PLANTATION OF SCOTCH PINE FOUR YEARS OLD, CHARLES DOWNER STATE FOREST.



A FOUR YEAR PLANTATION OF WHITE PINE ON THE CHARLES DOWNER STATE FOREST, SHARON.

Credit for sale of produce	$ 618.86
Credit for trees furnished Mendon forest	55.00
Credit for trees furnished Townshend forest	175.00
Credit for trees furnished Plainfield forest.......	110.00
	$ 958.86

L. R. JONES FOREST, PLAINFIELD.

The former policy of removing slow growing hardwoods and planting rapid growing softwoods, has been continued.

In the spring of 1914, 20,000 3 year Norway spruce transplants from the Sharon nursery, were planted on an abandoned pasture. An inspection later in the summer indicated that over 85 per cent had become established.

During the year the estimate of this forest has been completed, and is given below:

PLAINFIELD BLOCK. COMPARTMENT I.	BOARD FT.	CORDS.
Spruce,	1,050,000	
Balsam,	168,000	
Yellow birch,		560
White birch,		795
Maple,		184
Ash,		2
Beech,		37
		1,578
BARRE BLOCK. COMPARTMENT II.		
Spruce,	48,000	50
Spruce,	195,000	
Balsam,	39,000	
Yellow birch,		138
White birch,		4
Maple,		120
Ash,		8
Beech,		2
	1,500,000	1,900

BATTELL FOREST, CAMELS HUMP, DUXBURY AND HUNTINGTON.

The map and estimate of this forest have been completed, and show it to be the most valuable of all the State Forests. Col. Joseph Battell very generously gave this splendid area of spruce timber to the State in order that future generations of Vermonters may have an opportunity of seeing a tract of virgin timber. In keeping with the spirit of the gift, no appreciable state expense has been necessary for its upkeep, but it would be very fitting if the present good trail to the summit could be made into a wagon road, in accordance with the donor's wish. Camels Hump is, perhaps, our most picturesque mountain. It should be made accessible to all.

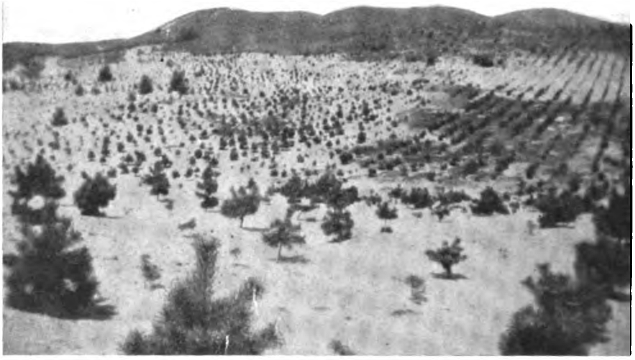
The forest plantation, made in 1913, has succeeded better than was expected, considering the elevation. The underbrush crowding the little pine and spruce was partially removed during the season.

ESTIMATE OF STAND.

HONEY HOLLOW BLOCK.	BOARD FEET.
Spruce,	3,066,000
Balsam,	206,000
Birch,	1,447,000
Maple,	272,000
HUNTINGTON BLOCK.	
Spruce,	1,380,000
Balsam,	184,000
Birch,	445,000
	7,000,000

LYNDON SAND FOREST PLANTATION.

The problem of controlling shifting sands is becoming more and more vital in such towns as Lyndon, where the open sand areas are increasing at an alarming rate. The State plantation has already done much to convince people of the neighborhood that pine, especially Scotch pine, will thrive on absolutely barren sand of this kind. Except on top of the main sand wave, all the plantations have been successful. There are at least 60 acres of thrifty growing plantations here from one to three years old. Experiments



TWO YEAR PLANTATION OF SCOTCH PINE ON SHIFTING SAND, LYNDON STATE FOREST.

SPLENDID NATURAL REPRODUCTION OF WHITE PINE IN MONKTON, VERMONT.

have been made with willow cuttings for checking the drifting sands. Of those set in 1913 on top of the wave, about 80% were alive a year later.

SUMMARY OF PLANTING IN 1912, '13, '14.

Scotch pine,	77,000
White pine,	35,600
Norway spruce,	3,000
Western yellow pine,	1,300
Pitch pine,	50
European larch,	200
	117,150

GEORGE AITKIN FOREST, MENDON.

The policy of removing slow growing hardwoods and replacing with quick growing softwoods, has been continued. During the winter 1,334 feet of spruce, and 5,320 feet of hemlock, besides 52½ cords of hardwood, were cut from the eastern portion of the tract.

In the spring of 1914, there were planted on this cut-over area and adjoining openings: 10,000 3 year Norway spruce transplants from the Sharon nursery; and 3,600 3 year red pine, 500 3 year spruce of various foreign species, 800 white ash, and 1,300 red oak from the Burlington nursery.

SUMMARY OF TREES PLANTED IN 1913 AND 1914.

White pine,	19,000
Scotch pine,	6,000
Red or Norway pine,	3,600
Norway spruce,	10,000
Varieties of spruce,	500
White ash,	800
Red oak,	1,300
	41,200

Five pounds of white pine seed was also sown in seed spots six feet apart. The leaf cover and sod was scraped from these spots with a mattock or hoe, and about twenty seed was sown in each spot and covered with a half inch of soil.

The detailed estimate of this tract was given in the last annual report. The total stand amounts to 320,000 board feet and 4,855 cords. The growth on the tract will more than counterbalance the wood and lumber cut since the estimate was made, although it has not as yet been accurately determined.

WEST RIVER FOREST, TOWNSHEND.

In order to stimulate an interest in reforestation in the West River valley, and also to have a nearby supply of stock for planting on the State land, a temporary transplant nursery was established just north of the village in the spring of 1914. This nursery is like the one maintained two years ago at Lyndon. No seed was sown, and it is not in any sense a competitor of the main nursery, but is used to create local interest.

The following trees were set out in transplant rows:

60,000	2 year red pines,
25,000	2 year white spruce
100,000	2 year red spruce
45,000	2 year white pine
16,000	1 year white ash
246,000	

On account of the extensive work on the highways in this vicinity, it was almost impossible to secure labor, and no attempt, therefore, was made to do any final planting.

In the fall of 1913, a very successful inspection was made of the forest by the people of Townshend.

The estimate of the forest was completed, and is as follows:

ESTIMATE OF WEST RIVER FOREST.

Spruce,	460	cords
Hemlock,	1,400	"
Yellow birch,	650	"
White birch,	500	"
Pine,	95	"
Ash.	25	"
Basswood,	40	"
Maple,	400	"
Beech and others,	430	"
Total,	4,000	"

The history of this forest furnishes an excellent example of the inequalities of taxation which exist in taxing timber lands under the General Property tax system. The tract was purchased by the State after it had been stripped of its merchantable timber. Below are the figures, given by the mill man, of the amount of lumber cut, and the stumpage value as estimated by him.

GROUT LOT:

Hemlock and spruce,	300,000 ft. @ $4.	$1,200.00
White pine,	136,000 ft. @ 7.	952.00
Beech, birch and maple,	124,000 ft. @ 2.	248.00
Poplar, oak, basswood and ash,	105,000 ft. @ 9.	945.00
		$3,345.00

OTHER LOTS:

Hemlock and spruce,	1,000,000 ft. @ $5.	$ 5,000.00
White pine,	350,000 ft. @ 8.	2,800.00
Beech, birch and maple,	721,000 ft. @ 3.	2,163.00
Basswood, white ash and oak,	116,000 ft. @ 10.	1,160.00
		$11,123.00
Total value of lumber removed,		$14,468.00

Previous to the time of cutting this timber the assessors' valuation of these various tracts amounted to $4,545. After the removal of $14,468 worth of timber, the grand list on this 700 acres of stripped land was $35.05. In other words, a difference of $1,040 was made for the removal of $14,468 in lumber. Obviously this tract was either assessed too low before lumbering, or too high afterwards; and this is by no means a peculiar case. Those conversant with investments in forest lands realize that culled lands are only a good investment when they can be secured at low prices and are assessed accordingly. There is little incentive to leave growing timber when it is to be overtaxed, and towns practicing such a system will suffer in the end by deforestation and reduced property valuation.

ARLINGTON FOREST.

Nearly all of the open land in this forest was planted in the spring of 1914, with the following:

White pine 4 year transplants,	10,000
White pine 3 year transplants,	16,000
Norway or red pine 3 year transplants,	20,000
	46,000

This tract is in a part of the State where there has been practically no interest in forestry. It was, therefore, very encouraging to note the stimulating influence which this state planting had upon private owners of the neighborhood, evidently bringing the matter home to them in a way it had not been previously brought.

A summary of the estimate of the tract, as given in the last report, is as follows:

2,100	chestnut ties,
2,300	cords of wood.

WEST RUTLAND FOREST.

In the fall of 1913 this tract, consisting of 350 acres, was purchased by the State. It is in the extreme northwest corner of the town, being on the east slope of the Tatonic range west of the True Blue Marble Mill. Like the Arlington tract, which is similarly situated, there is a considerable variation in elevation from about 900 to 1,800 feet. This is lease land, and is in two lots, one owned by the Episcopal Church, and the other is school land belonging to the town of Rutland. Like numerous lots throughout the State, the title to them cannot be secured, but a permanent lease is practically the same as a purchase. The State, in this case, pays rental to the church and town of Rutland instead of paying taxes to the town of West Rutland.

These church grants date back to about 1765, while Vermont was still a part of the British Colony of New Hampshire. Gov. Benning Wentworth, of the Colony, by authority derived from the King, in making grants to the townships, reserved to the Society for propagating the Gospel in Foreign Parts, certain portions of land in each town for the purpose of supporting the Church of England in the Colony of New Hampshire. After the Revolution, the Episcopal Church in 1795, sent Col. John A. Graham, of Rutland*, as agent to England to ask the Society to transfer these lands to the Episcopal Church of Vermont. At that time the request was refused, but later the lands were transferred, and are still so held.

The land consists of an abandoned farm with dilapidated buildings, and woodland. As the nearest portion is a considerable distance from the highway, it cannot be advantageously tilled. The old mowings and pastures will, therefore, be reforested. In the spring of 1914 there were planted on these:

10,000	4 year	white pine transplants
4,000	3 year	white pine transplants
10,000	3 year	red pine transplants
5,000	3 year	Norway spruce transplants

The lower areas were planted with pine, and the upper pastures with spruce.

The woodland is a very interesting mixture of northern and southern species. Red oak, paper birch, and spruce, mingle in a way that is seldom found. On one area the spruce was largely cut about ten years ago. Before cutting, the spruce had reproduced extensively, and the result is a splendid second growth of spruce under red oak and white birch. The latter should be removed, as it is mature, in order to give the spruce reproduction more light and moisture. On the upper slopes there is a greater per cent. of white birch.

The estimate of the tract is as follows:

	BOARD FT.	ADDITIONAL CORDS.
Spruce,	10,000	200
Oak,	90,000	200
Basswood,	90,000	
Ash,	20,000	150
Maple,	150,000	300
Yellow birch,	40,000	80
Poplar,		170
Beech and others,		400
White birch,	275,000	
	675,000	1,500

Total 675,000 Board Ft. plus 1,500 cords or
400,000|| Board Ft. plus 2,300 cords

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*See The Rural Magazine published in Rutland in 1796—Vol. II.

||Considering the white birch as cord wood.

MANSFIELD FOREST.

At the time of writing this report, August 1, 1914, the purchase has just been completed by the State of a splendid tract of 3,000 acres in the town of Underhill. It lies on the west side of the main range, just south of Mount Mansfield. The top of the divide passing through Nebraska Notch and over the summit of Mount Admiral Clark, forms the east line of the tract. It was originally a part of the old town of Mansfield, and was crossed by a once well used road passing through Nebraska Notch to Stowe. It would not require a large expenditure to improve this road, since it is well located with a good grade. From the standpoint of water supply the forest is important, since three large brooks originate on it; Stevens Brook, Clay Brook and Lee River. On the Clay Brook there is a very unusual fall or cascade, especially in spring. The perpetuation of these streams and the preservation of the fish in them, will be a great benefit to the community, not to mention the preservation of the scenery in one of the most beautiful parts of Vermont.

While the best spruce lumber was culled out about twenty-five years ago, the careless methods of cutting at that time, due to the low value of lumber, resulted in leaving a good deal of scattered spruce, as well as hardwood. With the exception of about one hundred acres at the north end, which have been severely burned, the whole area is well wooded, and offers an excellent opportunity for the practice of forestry, as soon as markets can be obtained for the poorer trees which must be gradually removed in order to make room for more valuable and rapid growing varieties. The price paid for this tract was about $3.20 an acre. On account of its location, size and growth, it is, perhaps, the most interesting forest yet acquired, and one which will attract much attention on the part of the public.

SUMMARY OF TREES PLANTED IN 1914 ON STATE FORESTS.

CHAS. DOWNER FOREST,—SHARON.

Norway spruce,	8,000	
White ash,	5,000	
		13,000

L. R. JONES, FOREST,—PLAINFIELD.

Norway spruce,		20,000

SAND PLANTATION,—LYNDON.

Scotch pine,	3,000	
Western yellow pine,	1,000	
White pine,	10,000	
		14,000

GEO. AITKIN FOREST,—MENDON.

Norway spruce,	10,000	
Red pine,	3,600	
Spruce varieties,	500	
White ash,	800	
Red oak,	1,300	
		16,200

ARLINGTON FOREST.

White pine,	26,000	
Norway or red pine,	20,000	
		46,000

WEST RUTLAND FOREST.

White pine,	14,000	
Red pine,	10,000	
Norway spruce,	5,000	
		29,000
		138,200

SUMMARY BY SPECIES.

White pine,	50,000
Scotch pine,	3,000
Red or Norway pine,	33,600
Western yellow pine,	1,000
Norway spruce,	43,000
Other spruce,	500
White ash,	5,800
Red oak,	1,300
	138,200

APPROXIMATE AREA AND STAND OF STATE FORESTS.

Name	Area Acres	Total Stand Board Feet	Ties	Cords
Charles Downer Forest,	800	¶		
L. R. Jones Forest,	600	1,500,000		1,900
Hapgood Forest,	100*	¶		
Battell Forest,	1,200	7,000,000		
Lyndon Plantation,	75	**		
Geo. Aitkin Forest,	850	320,000		4,855
West River Forest,	700			4,000
Arlington Forest,	225		2,100	2,300
West Rutland Forest,	350	675,000		1,500
Mansfield Forest,	3,100	¶		
	8,000			

EXPENDITURES TO JULY 1, 1914, UNDER NO. 28, ACTS 1912.

ARLINGTON FOREST.		
Purchase,	$1,450.00	
Survey,	57.30	
Planting,	526.62	
		$2,033.92
WEST RUTLAND FOREST.		
Purchase,	$1,200.00	
Survey and estimate,	160.80	
Planting,	258.87	
		1,619.67
WEST RIVER FOREST.		
Survey,	$ 15.40	
Planting,	282.71	
		298.11
LYNDON FOREST.		
Planting,		55.26
GEO. AITKEN FOREST.		
Planting,		131.94
		$4,138.90

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*Besides this forest Mr. Hapgood deeded to the state the control of about 800 acres additional.

¶No estimates have been made.

**No timber to estimate.

FOREST FIRES IN 1913.

As explained in the last report, it is more convenient to consider forest fires for the calendar year than for the state fiscal year. This system has, therefore, been adopted.

The spring and summer months of 1913 were, with the exception of July, the driest since 1908. This dry period not only affected the agricultural interests, but the forests of the State were in constant danger of fires.

The following table, made up from reports of the U. S. Weather Bureau, shows how 1913 compared with the four previous years in the number of inches of rainfall during each month.

INCHES OF RAINFALL BY MONTHS—SINCE 1909.

Year	April	May	June	July	August	Sept.	Oct.	Nov.
1909	3.0	4.6	3.1	2.6	3.1	4.2	1.5	2.0
1910,	2.4	3.8	2.9	2.4	3.7	4.5	2.0	2.5
1911,	1.1	1.3	3.9	3.5	3.9	3.8	4.1	2.2
1912,	2.7	6.4	1.8	2.7	3.9	5.3	4.1	3.3
1913,	1.9	3.3	1.7	3.7	1.5	2.2	4.9	2.0

From the foregoing table it appears that the months of June, August and September were the driest since 1908. While April and May had below the normal amount of precipitation for these months, they were not as dry as during 1911. It is interesting to note how the number of fires reported varied according to the amount of precipitation during the month. Of course, where two dry months came together, such as April and May, or August and September, the latter month usually has the greater number of fires, as the forests are very much drier during these months. For example, April had 26 fires, while May had 58, and likewise August had 21 fires, while September had 24. From the above table we notice that July had 3.7 inches of rainfall, the most for several years, and the corresponding number of fires during this month was only 9.

Not since 1908 has the State suffered such a dry period as during the spring and summer months of 1913. However, the cost of fighting fire this year was only about one-third of that during 1908, which was the year previous to the establishment of the Forest Service. In that year the cost was $10,769. The expenditure by the State of about $1,500 in fire prevention has probably saved it at least $6,000, for fire fighting, not to mention many thousands of dollars' worth of timber and young growth saved from destruction. As a matter of fact, most of the fires which occurred were extinguished before much damage was done, which is due chiefly to the forest fire protective system.

During the spring of 1913, this new forest fire protective policy was established, made possible by several recent laws enacted during the 1912 session of the General Assembly, and by the cooperation of the United States Government under the Weeks Law, as described in previous reports. In 1913 the Vermont Forestry Department set apart $1,500 for this work, and thus received from the Federal Government a like sum, making a total of $3,000 for the protection of the watersheds of navigable streams.

The state was divided into two ranges: Range I including the northwestern section of the state tributary to Lake Champlain, and range II the remainder of the state, covering the navigable watersheds. On the latter range only could the United States money be spent.

Each of these Ranges was put in charge of a ranger whose duty it was to keep in touch with the people living within his range, and to attend to all matters pertaining to fire protection. In each town there is a fire warden and in many towns, where the danger is great, a number of district wardens are appointed, who perform the same duties as the warden. Under No. 27 of the Acts of 1912, the fire wardens are appointed by the selectmen of the towns, provided, however, this is done by March first, each year. If the selectmen fail to appoint by this date, the State Forester has the power to appoint. This system is a great improvement on the previous law, since efficient fire wardens can thus be retained from year to year, regardless of political considerations.

The general plan of the protective system is to have one or more good wardens in each town; and to supplement this with a series of fire lookout stations in the wildest and most densely wooded sections; and to employ a number of patrolmen during the dry and dangerous periods of the year. Upon the first of these points, that is the warden system, depends in large measure the efficiency of the system. It will be admitted that no good fire protective system can be built up in Vermont until the people of the various towns realize the fact that forest fires are unnecessary, and are willing to turn out and extinguish small fires at once upon their discovery. The best way to attain this ideal condition is to have one or more efficient men in the town acting as fire wardens, whose business it is to see that all fires are promptly extinguished.

In several of the towns and gores of the state there are very few inhabitants, and in such places it has seemed advisable to have an additional protective force, such as lookout stations on the highest peaks, and patrolmen in places of danger. During the past year there have been lookout stations in operation on Gore Mountain in Essex County; Burke Mountain in the town of Burke; Camel's Hump in the town of Huntington, and Bald Mountain in Townshend. All these stations, which are located on peaks from which a commanding view of the surrounding country may be obtained, are equipped with telephone connections, cabin, and the two first named stations with towers. The Gore and Burke Mountains were established by private owners of woodlands in those sections, while the state established the other two which are located on state forests. The Gore Station is located in one of the wildest and most densely wooded areas of the State, commanding a view of some 100,000 acres of woodland. During the past season several fires were reported by the watchman. The danger in this section is especially great in view of the fact that extensive lumbering is being carried on, much of it being pulp jobbing, which is continuous both summer and winter. The other three stations, although not covering as large areas, are of considerable importance, as they overlook wooded regions in very mountainous localities. A fund was raised in the fall of 1913 by parties interested in the woodlands of the southern part of the State, for the erection of a lookout station on Stratton Mountain. At the time of writing a sixty foot steel tower is in process of erection, thus making it possible to see over the tops of the surrounding trees.

During the past season federal fire patrolmen have been employed during the extremely dry periods. These men have done much good work wherever they were located. There has been one man covering the timbered section of the southern part of the state, and while the section is far too large for one man to look after satisfactorily, his work has been of great value in making hunters, fishermen and campers more thoughtful in the use of fire in the woods. Another man has been located on the Rutland Section of the Green Mountain Trail, using Killington Peak as a lookout point. Three men have been employed as patrolmen along railroads during the extreme dry times, thus preventing the numerous small fires set by the locomotives from doing much damage. On a section of the Central Vermont Railroad for instance, where no patrolman was employed, one fire was started and burned over approximately 1,000 acres. This was the largest fire of the season, and probably would have been prevented if the railroad had taken the precaution of employing a patrolman for a few weeks in dry weather along the right of way.

During the year there were 167 fires reported from 96 towns. The total number of acres burned over amounted to about 5,635, which is less than two-tenths of one percent. (.2%) of the total forested area of the State. The total cost of fighting these fires amounted to $3,115.82, which was paid by the various towns in which the fires occurred, with the exception of $210.59 which was paid by the State in the case of a fire in the town of Stratton. This is the sum over five percent of the grand list of the town.

Over 70 percent of the fires were surface fires; 11 percent ground fires; 11 percent surface and ground; and the remaining 8 percent a combination of ground, surface and crown fires.

The areas burned over, and cost of fighting by counties, are as follows:

COUNTY.	ACRES BURNED.	COST OF FIGHTING.
Addison,	484	$ 480.77
Bennington,	358	70.43
Caledonia,	213	302.33
Chittenden,	495	169.25
Essex,	253	141.30
Franklin,	137	87.95
Grand Isle,	1	1.80
Lamoille,	129	70.11
Orange,	18	130.16
Orleans,	36	59.52
Rutland,	1,199	710.78
Windham,	437	433.51
Windsor,	532	185.25
Washington,	1,343	272.66
	5,635	$3,115.82

The reported fires were caused in many ways as follows:

CAUSE.	NUMBER OF FIRES.	PER CENT.
Unknown,	60	36
Railroad,	33	20
Brush burning,	15	9
Smokers,	16	9
Fishermen and hunters,	11	7
Berry pickers,	8	6
Spite fires,	7	4
Portable mills,	4	2
Lightning,	4	2
Caught from fires in buildings,	4	2

Picnickers,	3	2
Bee hunters,	2	1
Total,	167	100

Most of the fires occurred in the month of May, 58 being reported in this one month. Following are the months and the number of fires occurring in each:

March,	1	fire
April,	26	fires
May,	58	"
June,	24	"
July,	9	"
August,	21	"
September,	24	"
October,	2	"
November,	2	"

Over two-thirds of the fires which were reported burnt over less than 25 acres each. The following table shows the number and extent of the fires.

Number of Fires.	Size of Area Burned Over.	Total Acreage Burned.
127	Less than 25 acres each	739
17	Burned from 25 to 50 acres	500
9	Burned from 50 to 100 acres	580
11	Burned from 100 to 500 acres	1,816
3	Burned from 500 to 1000 acres	2,000
Total 167		5,635

One very evident conclusion from the foregoing statistics, is that more small fires have been reported this year, but that they burned over a smaller area than in previous years. This probably indicates that the wardens in the various towns are more active, both in reporting fires and also in extinguishing them before many acres are burned over. The three fires, which together burnt over approximately 2,000 acres, were in the towns of Wells, Middlesex and Sharon. The Wells fire started in a neighboring town and as it was not promptly put out by the officials there, it spread rapidly into the town of Wells where it was finally extinguished. In the case of the Middlesex fire, there was difficulty in getting men out, and meanwhile it spread over about 1,000 acres. The Sharon fire got under headway before anyone attempted to stop it. In all three of these fires, if the people of the towns had turned out at the beginning of the fire, very little damage would have resulted.

SUMMARY OF FIRES FOR 1913.

Town	Date	Duration	Cause	Area burned acres	Damage	Expense	Warden
Addison	June 14		Picnic Party			$ 5.00	L. M. Gage
Alburgh	May 9	1	C. V. R. R.	.3		.20	H. J. Booth
	May 15	3 hrs.	C. V. R. R.	.3		.60	H. J. Booth
	May 28	5 hrs.	C. V. R. R.	1		1.00	H. J. Booth
Athens	June 11	4 hrs.	Unknown	3	$ 90.00	15.16	F. E. Ober
Averill	May 5	9 hrs.	From roadside	3		5.00	J. C. Holmes
Bakersfield	May 4	24 hrs.	Unknown	75		1.50	O. J. Maynard
Barnard	April 21	4 hrs.	Saw-mill	5	50.00	3.25	C. L. Sleeper
Barre	Sept. 28	3 wks.	Hunters	2	30.00	12.00	D. T. Gregory
	Sept. 1	6 hrs.	Brush burning	5		1.00	D. T. Gregory
	Aug. 15	2 mths.		2		10.00	D. T. Gregory
Barton	May 8	6 hrs.	Unknown	3		3.00	E. R. Cook
Benson	Sept. 6	13 dys.	Fishermen	7	100.00	43.60	D. L. Barber
	Sept. 28	7 dys.	Brush burning	5		17.00	D. L. Barber
Bethel	June 5		Unknown			21.00	W. H. Smith
Bloomfield	May 1	3 dys.	G. T. R. R.	10		3.75	Geo. R. Monell
Bolton	May 4	8 hrs.	Unknown	7		3.50	E. E. Hall
Braintree	May 3	3 hrs.	Brush burning	.5		1.50	Wm. Ladue
Brattleboro	April 22	1 hr.	B. & M. R. R.	1	25.00	3.50	F. R. Thomas
	June 30	1 hr.	B. & M. R. R.	.5	10.00	3.00	F. R. Thomas
	April 19	4 hrs.	Brush burning	25		3.66	J. G. Stafford
	April 15	1 hr.	B. & M. R. R.	2		2.20	F. R. Thomas
	April 10	1 hr.	B. & M. R. R.	.5		1.00	F. R. Thomas
Bristol	April 26	4 hrs.	Brush burning	10		3.40	Geo. S. Farr
	May 4	12 hrs.	Unknown	20	200.00	11.50	Geo. S. Farr
	Sept. 8	7 dys.	Bee hunters	100	300.00	212.54	Geo. S. Farr
Brunswick	May 3	2 dys.	Dropped match	40	50.00	25.00	James Conn
Cabot	May 9	1 hr.	Pipe	2		1.50	S. J. Norris

Castleton	May 11	4 dys.		175		17.20	H. P. Morgan
	May 20	1 day		10		3.00	H. P. Morgan
	Aug. 15	8 dys.	Unknown	300	50.00	116.25	H. P. Morgan
	Aug. 26	1 day	Berry pickers	5		4.80	H. P. Morgan
Colchester	July 1	24 hrs.	Unknown	5		4.23	Eug. Hamilton
Concord	May 6	5 dys.	Unknown	200	325.00	112.55	E. A. Morse
Cornwall	July 4	16 hrs.	Smoker	5		10.00	F. E. Foote
Craftsbury	May	12 hrs.	Unknown	1	50.00	21.65	W. P. Kaiser
Danville	June 11	18 hrs.	Unknown	3		1.88	F. E. Allen
Dorset	Aug. 20	2 dys.	Berry pickers	6	25.00	10.25	A. A. Roberts
Dover	July 18	6 hrs.	Unknown	3			Dorr F. Fitch
Dummerston	May 1	3 hrs.	Match dropped	3			W. W. Burnham
	April 15	3 hrs.		3	50.00		W. W- Burnham
	May 15	2 hrs.	Cigarettes	.5			W. W. Burnham
Duxbury	Sept. 28	30 hrs.	Smoker	3	10.00	16.02	Philip Shonio
	Aug. 20	52 hrs.	Berry pickers	.5	15.00	22.09	Philip Shonio
Essex	May 12	1 hr.	C. V. R. R.	1		.35	David Demag
	May 15	4 hrs.	Smoking.	3		4.25	David Demag
	May 12	2 hrs.	C. V. R. R.	8		1.00	David Demag
	May 7	4 hrs.	Unknown	7		9.85	David Demag
	May 6	6 hrs.	Incendiary	17		13.75	David Demag
	May 9	8 hrs.	C. V. R. R.	35		27.00	David Demag
	May 10		Incendiary	10		13.40	David Demag
	May 8	5 hrs.	Incendiary	1		3.25	David Demag
	May 8	4 hrs.	C. V. R. R.	30		12.80	David Demag
	May 3	4 hrs.	C. V. R. R.	4		2.40	David Demag
	April 23	2 hrs.	C. V. R. R.	4		2.20	David Demag
	April 26	3 hrs.	C. V. R. R.	4		2.85	David Demag
	April 26	3 hrs.	Incendiary	1		2.30	David Demag
	April 23	5 hrs.	Carelessness	7		3.75	David Demag
	April 21	5 hrs.	C. V. R. R.	2		2.25	David Demag
	Mar. 19	4 hrs.	C. V. R. R.	40		6.65	David Demag
	Sept. 9	4 hrs.		4		8.00	David Demag
	Sept. 4	4 hrs.	Berry pickers	6		9.00	David Demag
	Sept. 7	4 hrs.	Berry pickers	2		3.00	David Demag

SUMMARY OF FIRES FOR 1913—(Continued).

Town	Date	Duration	Cause	Area burned acres	Damage	Expense	Warden
Essex	Nov. 7	5 hrs.	C. V. R. R.	50		$ 12.47	David Demag
Fairfax	Sept. 2	5 hrs.	Unknown	1		5.00	G. T. Rooney
	Aug. 21	5 dys.	Unknown	10	$200.00	59.70	G. T. Rooney
Fair Haven	Aug. 20	2½ dys.	Match dropped	50		45.00	E. W. Morse
Ferrisburg	Aug. 25	4 dys.	Unknown	5		5. 7	C. R. Hawkins
Fletcher	April 0	24 hrs.	Portable mill	37	100.00	14.00	C. F. Corse
Georgia	April 27	12 hrs.	C. V. R. R.	.5			F. W. Bliss
	Sept. 7	15 hrs.	C. V. R. R.	6		2.00	F. W. Bliss
Greensboro	May 12	10 hrs.	Brush burning	1.5	10.00	5.00	J. Irwin Wilson
Groton	Sept. 9	2 hrs.	W. R. R. R.	15		1.75	H. M. Ricker
Guilford	June 30	2 hrs.	Hunters	3			E. E. Gaines
Hardwick	May 13	10 days.	Hunters	100		210.00	C. A. Stanford
Hartland	April 26	3 hrs.	Locomotive	1	90.00		J. G. Britton
Huntington	May 4	1 day	Incendiary	2		3.50	A. J. Swinyer
	April 27	3 dys.	Unknown	50		21.24	A. J. Swinyer
Hyde Park	May 6	48 hrs.	Unknown	75	350.00	21.48	H. A. Davis
	April 22	2 dys.	Unknown	35		4.63	H. A. Davis
Jamaica	Oct. 1	24 hrs.	C. V. R. R.	25		1.50	A. H. Coleman
	May 4	4 hrs.	C. V. R. R.	9	25.00	16.75	L. E. Grout
	June 14	2 dys.	Portable mill	15		3.30	L. E. Grout
Leicester	May 6	7 hrs.	Unknown	8	62.00	13.75	Geo. E. White
Ludlow	July 23		Lightning	1	15.00	10.00	J. Wilmoth
Marlboro	July 7	3 dys.	Unknown	3.5		4.00	C. N. Perry
Mendon	May 7	5 hrs.	Unknown	3		.75	G. H. Bristol
	Aug. 18	2 dys.	Unknown	10		3.00	C. A. Rich
	Nov. 6	2 hrs.	Unknown	10	20.00	3.00	C. A. Rich
Middlebury	Aug. 8		Unknown	140	450.00	74.21	H. E. Everts
	May 11	3 dys.		30		27.61	H. E. Everts

Middlesex	May 1	3 dys.	C. V. R. R.	1000	1000.00	30.20	B. W. Daniels
	Aug. 25	3 dys.	Berry pickers	20	25.00	29.30	Jos. A. Chapin
Milton	Oct. 10	48 hrs.	Hunters	200		17.50	B. D. Martin
Monkton	May 4	14 hrs.	Unknown	125	200.00	37.50	B. L. Lawrence
Montgomery	April 2	8 hrs.	Brush burning	7		5.75	A. R. Gates
Montpelier	May 6	2 hrs.	Unknown	2			W. A. Potter
	May 3	3 hrs.	Unknown	2			W. A. Potter
	April 26	1 hr.	Unknown	2			W. A. Potter
Morgan	May 4	3 dys.	Unknown	25		28.00	E. J. Batchelder
Morristown	Sept. 28	24 hrs.	Unknown	.5	25.00	7.25	J. L. Staples
	April 26	5 hrs.	Incendiary	30	200.00	15.50	J. L. Staples
Marlboro	June 29	3 mos.	Unknown	150	400.00		C. N. Perry
Mount Holly	July 23	13 dys.	Lightning	.5		47.55	C. A. Gates
Mount Tabor	Sept. 2	20 hrs.	Smoking	3		27.29	W. H. Allen
	May 15	3 hrs.	Rutland R. R.	1		1.00	W. H. Allen
Newark	May 10	2 dys.	Unknown	1		6.25	Wallace Hudson
Newfane	July 15	1 hr.	C. V. R. R.	.5			H. J. Heath
Newport	Sept. 2	2 dys.	Brush burning	1.5		1.87	Eug. Labounty
Northfield	April 23	3 hrs.	Smoker	30	15.00	18.00	G. B. J. Edwards
	Sept. 28	78 hrs.	Unknown	2	25.00	15.00	G. B. J. Edwards
	Sept. 29	18 hrs.	Hunters	1	10.00	10.80	G. B. J. Edwards
Orange	Sept. 11	4 dys.	Roadside	2		11.29	G. E. Nelson
Orwell	Sept. 12	5 dys.	Unknown	40	150.00	100.00	F. Conway
Peacham	Sept. 8	2 dys.	Unknown	1	20.00	4.20	Leonard Welch
Peru	May 2	2 hrs.	Brush fire	25			S. J. Whitney
Pittsford	July 2	7 dys.	Lightning	9	200.00	41.47	P. E. Mooney
Plainfield	May 2	3 hrs.	Smoker	30			John Foss
Poultney	Aug. 2	12 hrs.	Unknown	10		21.00	M. B. Carvay
Randolph	May 12	4 dys.	Brush burning	15		38.67	C. C. Gifford
Rockingham	April 18	6 hrs.	Brush burning	70	100.00	17.05	H. A. Stoddard
	May 3	2 hrs.	Rutland R. R.	2		.50	H. A. Stoddard
Royalton	June 11	7 hrs.	C. V. R. R.	5		7.25	W. H. Smith
Rutland	May 11	4 hrs.	Smokers	.5		1.20	F. B. Clark
	Aug. 17	4 hrs.	Berry Pickers	5		7.95	John Callahan
Ryegate	June 8	12 dys.	Fishermen	100	1000.00	75.00	C. A. Meader

SUMMARY OF FIRES FOR 1913—(Concluded).

Town	Date	Duration	Cause	Area burned acres	Damage	Expense	Warden
Searsburg	June 16	4 hrs.	Deerfield V. R. R.	2		1.88	W. E. O'Brian
	May 14	2 dys.		40	120.00	10.00	W. E. O'Brian
	May 6	10 dys.	Deerfield V. R. R.	150	450.00	1.00	W. E. O'Brian
Sharon	April 22	.5 hrs.	Smoker	500	600.00		Leland Rich
Shrewsbury	Aug. 25	18 hrs.	Unknown	1		18.00	E. E. Aldrich
Springfield	April 22	6 hrs.	Unknown	2		2.00	W. D. Stearns
	Aug. 20	2 dys.	Unknown	3		50.00	W. D. Stearns
Stamford	June	12 hrs.	Unknown	50		6.00	W. H. Seeger
Starksboro	May 10	7 hrs.	Unknown	6		7.50	A. E. Clifford
Stratton	June 18	11 dys.	Fishermen	30	2000.00	291.40	D. H. Forrester
Stowe	May 9	6 hrs.	Fishermen	5		10.50	Craig O. Burt
Sunderland	April 18	6 hrs.	Unknown	80	225.00	16.30	I. M. Bentley
	Aug. 19	36 hrs.	Berry Pickers	5	20.00	25.00	E. G. Bacon
Topsham	Aug. 14	24 hrs.	Fishermen			11.00	J. K. White
Townshend	June 14	6 hrs.	Smoker	10	5.00		P. D. Chamberlin
	June 14	1.5 hrs.	C. V. R. R.				P. D. Chamberlin
	July 25	.5 hrs.	C. V. R. R.	.5			P. D. Chamberlin
	June 15	.5 hrs.	C. V. R. R.	.5			P. D. Chamberlin
Vernon	Aug. 18	2 dys.	Brush burning			10.00	E. Stebbins, Jr.
Wallingford	April 22	2.5 hr.	Brush burning	1		10.00	R. W. Hopkins
	April 26	15 hrs.	Unknown	30	75.00	25.00	R. W. Hopkins
	Aug. 3	7 hrs.	Unknown	20		5.00	R. W. Hopkins
	Sept. 9	4 hrs.	Spark. fr. barn	1		4.00	R. W. Hopkins
Waterbury	Sept. 9	1 hr.	Picnickers			14.00	Geo. W. Grover
	May 1	3 hrs.	Unknown	40		59.00	Geo. W. Grover
Waterville	May 4	5 hrs.	Fishermen		100.00	10.75	G. M. Morrison
Wells	June 29	6 dys.	Unknown	500		254.82	G. D. Carter
West Haven	June 15	6 hrs.	Unknown	1		4.00	G. T. Bigelow

	June 20	8 dys.	Unknown	2	10.00	3.25	G. T. Bigelow
	Sept. 16	1	Unknown	2	20.00	5.50	G. T. Bigelow
Westminster	July 5	5 dys.	Lightning	25		30.96	C. H. Spaulding
	June 28	7 hrs.	Unknown	50		29.53	C. H. Spaulding
Weston	June 13	5 dys.	Portable Mill	2		42.25	W. S. Shattuck
W. Rutland	Aug. 20	2 hrs.	Spite fire.	6			John Nolan
Wheelock	May 12	1.5 dys.	Brush burning	7			L. L. Leavitt
Williamstown	July 29	10 hrs.	Picnic Party	.5		3.00	E. P. Clogston
Woodbury	May 6	4 hr.	Smoker	.5			J. B. Fair
	May 3	24 hrs.	Brush burning	200	100.00	12.00	Lee Daniels
	Sept. 13	6 hrs.	Unknown	.5	bldg.	2.00	J. B. Fair
Woodstock	June 11	15 hrs.	Smoker	6		49.50	J. E. Curtiss
Worcester	May 11	5 hrs.	Hunters	2	50.00	14.00	E. E. Howison
Total.				5,635.6	$9.847.00	$3,115.82	

TRAIL CONSTRUCTION.

As in previous years, the Department, through the use of federal patrolmen, has cooperated with the Green Mountain Club in the work of constructing the so-called "Long Trail". Previous to 1913 the trail had been mostly on paper, as there had been no sufficient funds to work with. Interest aroused by the trail constructed by the Department in 1912 between the Woodstock Stage Road and Killington Mountain, lead to several very generous donations on the part of public spirited citizens. These, together with appropriations of the various sections of the Green Mountain Club, and a substantial assistance from the Appalachian Club of Boston, made possible in 1913 a rough trail from Mount Mansfield on the north to Killington on the south, a distance of about one hundred and fifty miles. The portion of this trail lying south of Camel's Hump was located by the Forestry Department on a 15 per cent. grade. So far as is known this is the longest continuous trail in the East, and if properly developed should prove an important agency in developing Vermont as a summer resort, and what is of more importance, in encouraging the people of the State to tramp over our mountains. While it would be well to extend the trail eventually to the Berkshires in Massachusetts, as has been suggested, the money available during the next few years can be spent to better advantage in completing the portion already begun. Vermont should have not only the longest, but the best trail in the East.

The Forestry Department has been particularly active in the development of this trail following the policy of the various forestry departments in Europe, which have done so much to develop the tourist business. Aside from this however, the trail will be of great benefit in making the mountain sections easily accessible for fire fighting. If the land owners can be persuaded to equip telephone stations at convenient points, the efficiency of the patrol service will be greatly strengthened.

FINANCIAL STATEMENT JULY 1, 1914.

Salaries, State Forester and Assistants,	$ 3,769.06
Downer State Forest,	2,508.42
State Nursery,	2,199.09
Fire Prevention,	979.07
Railroad, livery, hotels, etc., Forester and Assistants,	865.87
Clerical force,	616.25
Townshend State Forest,	341.59
Investigations,	300.00
Postage, stationery, telephone and telegraph,	282.96
Printing,	161.93
West Rutland State Forest,	115.87
Disease eradication,	114.72
Lyndon State Forest,	81.00
Instruments, tools and office supplies,	75.71
Camel's Hump State Forest,	68.41
Freight and express,	52.02
Plainfield State Forest,	46.54
Insurance,	17.25
Geo. Aitkin State Forest, Mendon,	11.22
	$12,606.98

MONIES TURNED INTO STATE TREASURY.

Burlington—State Nursery,	$ 981.61
Sharon—Charles Downer State Forest,	618.86
Mendon—Geo. Aitkin State Forest,	164.70
Travelling and contingent exp. (refund from private parties),	18.81
Plainfield—L. R. Jones State Forest,	15.00
Townshend State Forest,	8.00
	$ 1,806.98

SEVENTH

ANNUAL REPORT

OF THE

STATE FORESTER

FORESTRY IN VERMONT

AUSTIN F. HAWES
State Forester

1915

ST. ALBANS, VT.
ST. ALBANS MESSENGER COMPANY
1915.

TO THE GENERAL ASSEMBLY OF VERMONT.

In compliance with Section 2 of Act No. 11 of the Acts of 1908, I have the honor to transmit herewith my report on Forestry in Vermont.

AUSTIN F. HAWES,
State Forester.

Burlington, Vermont, July 1, 1915.

EDUCATIONAL WORK.

As in previous years the Forestry Department has cooperated with the Extension Service of the University of Vermont and State Agricultural College in the teaching of forestry at the short courses about the State; also with the county agents in holding forest conferences in several of the counties. Mr. Sweeton of Windham County; Mr. Coryell of Windsor County, and Mr. Sherman of Bennington County, have taken special interest during the year in advancing the forestry cause in their respective counties. Many addresses have been given at grange and other meetings, and forestry exhibits have been made at the various agricultural fairs as in previous years.

The following publications have been issued since the last report:

Publication No. 15. "Studies in Tolerance of New England Forest Trees,"—Bulletin 181 of the Vermont Agricultural Experiment Station, by George P. Burns and Francis P. Hooper. This bulletin containing the results of an important series of experiments conducted by Prof. Burns is one of the most important publications in the country on this line of work.

Publication No. 16. "The Chestnut Bark Disease in Vermont," by R. M. Ross, contains a map showing the distribution of chestnut in the State and gives information about this serious tree disease which has found its way into Vermont during the past few years.

Publication No. 17. "Forest Planting in Vermont as an Investment," by A. F. Hawes, is designed to give the results of all forest planting work thus far done in the State and to present information about planting in a concise form, especially tables of probable yield, profit, etc.

FOREST BEQUESTS BY COL. JOSEPH BATTELL.

Probably the largest event of the past year in the forest history of Vermont was the bequest of a tract of about 25,000 acres by the late Col. Joseph Battell to Middlebury College. This splendid area comprises much of the main Green Mountain range from Lincoln Mountain on the north to Mount Horrid on the south. It includes Bread Loaf Mountain and the famous Inn at its base. Much of the land is covered with valuable spruce timber, although certain areas had been cut off before they were acquired by Col.

Battell. The gift of this fine park to Middlebury College practically insures the proper conservation of these splendid forests. Already the executors of the estate have undertaken the improvement of the property by the planting of approximately 100,000 trees on open areas. These trees had been grown by the Botany Department of the College, and much of the planting was done by the students under the direction of the State Forestry Department.

In addition to this area left to the College, and the Camel's Hump tract previously given to the State, Col. Battell left an area of about 3,000 acres on Lincoln Mountain to the United States Government.

At the request of the United States Forest Service, the Vermont Forestry Department has made an examination of this tract. A copy of the report submitted to the Government is included elsewhere in this report.

The ownership by the Federal Government and the College of these large areas, together with the state forests described elsewhere, insures the proper handling of the forests on an appreciable portion of the Green Mountain range. It is, of course, vital to the interests of the State that the forests on the upper mountain slopes be maintained, not only because of their value to permanent industries, but because of their influence on the water supply.

VERMONT TIMBERLAND OWNERS' ASSOCIATION.

Another matter of public interest in the forestry movement is the formation of the Vermont Timberland Owners' Association. This is similar to an organization which has been in existence in New Hampshire for some time and has been active in the prevention of forest fires. Its membership includes many large lumber companies owning approximately 275,000 acres of Vermont forests upon which it levies an annual assessment of one cent an acre for the employment of forest patrolmen and lookout men in cooperation with the Vermont Forestry Department.

FOREST TAXATION.

As mentioned in previous reports, the overtaxing of forests is a serious menace to the raising of timber, and also to the prosperity of many Vermont towns. There are comparatively few tracts where timber is assessed at more than its true value, but the fact that it is considered as real estate and taxed year after year, instead of as a crop, makes an assessment approaching its real value a great hardship to the owner. There seems to be an opinion among local listers that timber grows much more rapidly than it does. As a matter of fact there are undoubtedly woodlots in nearly every town the growth upon which would fail to pay for the taxes. Much of the rocky mountainous land of the state is not, in itself, worth over one or two dollars an acre, yet because the wood upon it may bring its sale value up to five dollars it is assessed at that price. A tax on such a valuation paid annually until the timber is ready to cut would, if figured at compound interest for that period, eat up a large part of the profit.

The fairest way of assessing forest land is evidently to tax only the land itself while the timber is growing and tax the timber or wood when it is cut. This is the principle underlying No. 40 of the Acts of 1912. It is evident that if this principle were immediately applied to all the woodlands of the State it would mean a great hardship to many towns and a raise of taxation of other forms of property. This law, however, will not cause the loss of a dollar in taxes to any town, but if taken advantage of will eventually mean large returns to the towns in the form of increased taxes. At present it can be be only applied to lands upon which the growth has no value, or as the law says, to land upon which the growth is less than fifteen years old. Lands of this kind when classified under this law cannot be assessed at over $3 an acre until 1950, but there is a yield tax of 10% of the gross stumpage value of the timber when it is cut. To take advantage of this law land owners apply to the State Forestry Department. Up to July 1, 1915, the department had examined five areas under this law as follows:

1.	Estey Organ Company	18	acres in	Marlboro
2.	" " "	2	" "	Brattleboro
3.	Hon. Mason Stone	100	" "	Plainfield
4.	Ernest C. Carpenter	6	" "	Plymouth
5.	E. R. Fellows	5	" "	Topsham

As the above mentioned law can apply only to land covered with young growth it does not apply to the large areas of forest lands. No. 41 of the Acts of 1912 is intended to apply to these. It is expected that it will be taken advantage of as a temporary measure, and that lands classified under it will eventually come in under No. 40. Practically all kinds of forest land can be classified under No. 41 and will thereafter be assessed as in the previous quadrennial appraisal. The assessed value of these lands cannot be increased after classification until 1950. To take advantage of this law the owner should secure application blanks from the Forestry Department.

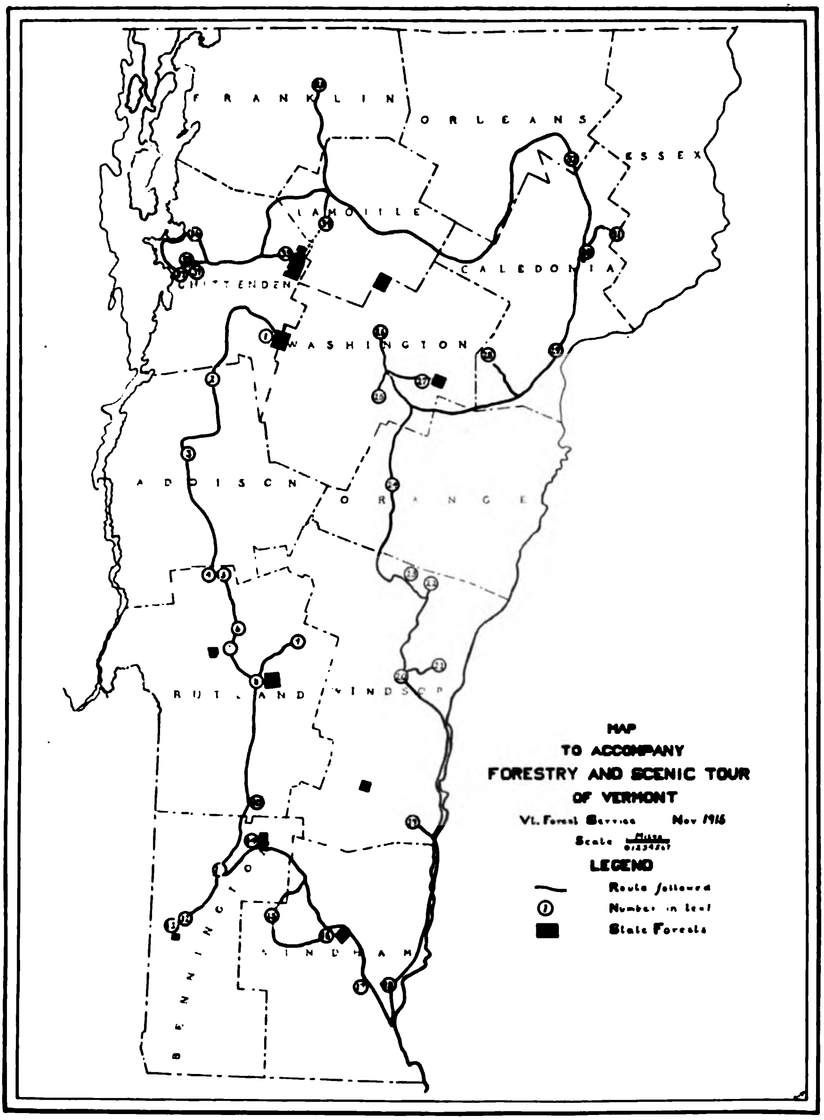
Inspection of the land, however, is made under this law, by the town listers.

OUTLINE OF A FORESTRY AND SCENIC TOUR OF VERMONT.

Instead of including in this report a list of the parties advised on forestry, as in the previous report, the writer has decided to describe briefly in the following pages some of the more interesting examples of forestry work. While it is doubtful whether any one will wish to make the whole trip as outlined, it is felt that there are many who would like to inspect some of the forestry undertakings in their own neighborhood. For the purpose of presenting these in a systematic way, an automobile tour of the State is outlined, and some of the more striking scenic features are included in order to give it general interest. No attempt is made to give distances or to point out roads, because these can be ascertained from the automobile blue book which is in common use. The general plan of the tour is to go south from Camel's Hump through the west side of the State, cross the mountains and come north on the east side returning to Burlington through the northern counties. Each point of interest is numbered in the order in which it would naturally be visited.

1. Camel's Hump Mountain, elevation 4,088 feet, can most easily be ascended from North Duxbury. A drive of three miles brings one to the foot of the mountain, where one should be careful to take the new trail made by the Forestry Department. From this trail can be inspected on the north side the forest plantations and fire lines described in this report under Camel's Hump Forest. Just below the Hump is the Camp maintained by the Camel's Hump Club of Waterbury for the accommodation of climbers. This is also a state fire lookout station. From the summit is a splendid view of Lake Champlain and the Adirondacks on the west; on the other side most of eastern Vermont with glimpses of the White Mountains; and north and south the great forest stretches of the Green Mountains.

Descent can be made by the new forest trail on the west side of the mountain down into Honey Hollow meeting the automobile at the point where this valley enters the main Winooski valley, about two miles east of Jonesville and south of the river. In descending this way one passes through some of the splendid virgin spruce timber given


MAP
TO ACCOMPANY
FORESTRY AND SCENIC TOUR
OF VERMONT
Vt. Forest Service
Nov 1916
Scale
Miles
0 1 2 3 4 5 6 7
LEGEND
Route followed
Number in text
State Forests
FRANKLIN
ORLEANS
ESSEX
LAMOILLE
CALEDONIA
CHITTENDEN
WASHINGTON
ADDISON
ORANGE
RUTLAND
WINDSOR
BENNINGTON
WINDHAM

the State by Col. Battell, and crosses the famous slide which is well worth a visit.

2. Touring south on the west side of the mountain range to Monkton Ridge. On the farm of D. W. Eddy is one of the best managed pine lots in the state. Although only four acres in extent and about fifty years old, the owner has successfully thinned it three times. The first time he removed fifty cords of wood which just paid for cutting. Later he cut some small logs at a slight profit. In the third thinning, made in 1913, he removed about 6,000 feet per acre at a profit of about $72. This was about one-fifth of the stand at that time. Just below this was an older piece which the owner cut clean in 1913. The previous thinning in this piece had resulted in a remarkable reproduction of pine which is now left to form a second generation.

3. Going south one sees on the steep slopes east of New Haven Junction the evil effects of bad lumbering followed by forest fires. Lake Dunmore should be visited as it is one of the most picturesque bodies of water in Vermont. Rising precipitously from its eastern borders is Mount Moosalamoo which can be easily climbed, and commands a beautiful view of the surrounding country, especially of the rich Champlain valley to the west. On this climb one should see the waterfalls just above the lake. The development, in the near future, of a large electric power plant near this lake, makes an early visit desirable.

4. At Forestdale is the interesting factory of the Newton & Thompson Company, where bobbins and numerous novelties are made. This Company has several woodlots in the neighborhood which have been thinned out under the direction of the Forestry Department. As the Company utilizes a large amount of lumber it plans to handle its woodlands so as to maintain a permanent supply. It also has some extensive pine plantations now three or four years old.

5. Just east of the kaolin works near Forestdale is a woodlot belonging to Miss Julia Jackson, in which she made a reproduction cutting in 1910. This lot was a mixture of large white pine, oak, poplar, white birch, etc. The purpose of the cutting was to derive a profit from the mature timber and at the same time secure natural reproduction of white pine. Scattered white pines were left for seed purposes and a scant cover of birch and poplar was left to shade the ground.

6. Near the village of Pittsford is the Vermont Sanatorium, a model home for tuberculosis patients. Belonging to this institution and surrounding it is a forest tract of

approximately one hundred acres. The Forestry Department made a map and working plan of this tract in 1911, and during succeeding years the recommendations have been carried out. A considerable quantity of lumber and wood has been thinned out and small areas have been planted. The forest is now in much better condition than it was at the beginning of the period, and a considerable profit has been derived.

7. Near the village of Proctor is perhaps the finest grove of large white pines now remaining in the State. Many of these trees are three to four feet in diameter and contain over 1,000 feet of lumber. It is one of the few remnants of this splendid timber which was once so common in the Champlain valley.

8. In the south-west corner of the town of Mendon is the George Aitken State Forest, a tract of 850 acres described elsewhere in this report. The chief thing of interest here is the plantation of white and Scotch pine made in 1913, and the later plantation of spruce on cut-over land.

9. Taking the Rutland-Woodstock stage road one reaches the top of the pass in nine miles. Here the Long Trail crosses the road and it is an easy climb to the summit of Pico Mountain, elevation 3,967 feet. The trip to the summit of Killington, elevation 4,241 feet, and return can be made comfortably in a day. From each of these mountains there is a splendid view of the great forested backbone of the State. On the former Mr. Mortimer Proctor, the owner, has erected a tower which is used as a fire lookout station.

10. Touring south up the valley of the Otter Creek one passes in the town of Mount Tabor the most notable example of destructive lumbering followed by fire that can be found in the State. This barren west slope was formerly a valuable forest growth. The fire which occurred in the summer of 1914 swept up the slope through the dry tinder left by lumbering, at a terrific rate, and was only put out after a great deal of hard labor at a cost to the State of over $1,000.

11. The valley through Dorset and Manchester is one of the most strikingly beautiful in New England and the village of Manchester has become rightly famed throughout the country. It is the summer home of several prominent people.

12. In the town of Arlington is a forest plantation of nearly forty acres started in 1913, of interest, chiefly because it was made for two small chilldren. Mr. John R. Fisher, the father, writes that not over five per cent of the trees died during the first summer and autumn.

13. In the same town on the border of Shaftsbury is

the Arlington State Forest, described elsewhere in this report. It is chiefly of interest as being one of the most northerly stations at which chestnut is found, and for the plantations of white and Norway pine. Examples of the destructive Chestnut Bark Disease may be found in this region.

14. In order to cross the mountain range it is necessary to return through Manchester and take the Peru turnpike, the only toll road in the State. In the town of Peru is situated Bromley Mountain, where there is a State park of one hundred acres given to the State by Hon. M. J. Hapgood, the owner of the hotel. Mr. Hapgood also gave to the State the control of about eight hundred additional acres. So far as is known this is the only case of the kind in New England. It is a common practice in Europe for land owners to give the control of their property to the state, since it safeguards the heirs against temptations to over-cut.

15. Stratton Mountain, elevation 3,859 feet, may be reached through Jamaica or Wardsboro. The ascent is an easy one, either by the Long Trail or that of the Stratton Mountain Club. On the summit is a fire lookout station and tower. This tower probably commands a view of the largest forest area in Vermont. In all directions, but especially to the south and west, the country is rolling and covered with timber. It is very unfortunate that this whole area will soon be cut clean by one or two out-of-state concerns, and the land will be left barren and next to useless for a generation or more. The whole of southern Vermont can be seen from this mountain.

16. Directly east of this mountain, near the village of Townshend, is the West River State Forest; described elsewhere in this.report. The chief point of interest here is the high hill, which is ascended by a good forestry trail. For the length of the climb the view is very extensive, including Ascutney Mountain in the north-east, Monadnock to the south-east, Bromley, Stratton and Haystack on the west. The trail is typical of those which the Forestry Department intends making on all the state forests, being laid out on a fifteen per cent grade. There are some excellent plantations of white and Scotch pines near the highway bridge.

17. The trip down the West River to Brattleboro is one of the most beautiful drives in the State. In the vicinity of Brattleboro are several private plantations, now large enough to be worthy of a visit. Among them may be mentioned those of Mr. Charles Richardson, Mr. E. B. Barrows, Holden & Martin, all of Brattleboro, and the Scott Farm in Dummerston.

18. In the town of Dummerston there is an interesting plantation of white pine about twenty-five years old, owned by Mr. Myron Dutton.

19. Continue north up the Connecticut valley to Springfield, which is one of the most thriving industrial centers of Vermont. Here are some very extensive and interesting plantations, among them the white and Jack pine plantations of Hon. James Hartness, which are now considerably higher than a man; the fifty acre plantation of white pine belonging to Mr. W. D. Woolson; and the white pine planted by Mr. F. E. Spellman in six different years.

20. In going north from here the road passes around the base of Ascutney Mountain into the historic and interesting village of Windsor. Here we leave the Connecticut valley and go across country to Woodstock, perhaps the best known village of Vermont because of its old colonial houses and beautiful estates. There are many successful forest plantations in this vicinity, the oldest in Vermont being those on the Billings estate. There is a small plantation of Norway Spruce over thirty-five years old; and larger plantations of white pine, European larch, and white ash approaching this age. There are also extensive plantations of pine and spruce between five and ten years old. Within a few miles of the village are numerous young plantations belonging to A. L. Powers, Mrs. A. B. Morgan, Col. F. S. Billings, Cloudland Farm, the Bridgewater Woolen Company and others.

21. Several miles east of Woodstock is the deep cut cannon of the Ottaquechee River, one of the wonders of Vermont. It should be included in a state park.

22. Travel north through Pomfret and visit the state forest in Sharon which was given to the State by Hon. Charles Downer of that place. The plantations or white, Scotch and Norway pines, made here in 1910 and subsequent years, now cover over one hundred and fifty acres and are among the most interesting in the State. Many of the trees are twelve to fifteen feet high and are making an annual growth of about thirty inches. The white pine has grown faster than any of the others. There are also younger plantations of other species such as the Norway spruce, European larch, white ash, Western red fir, etc.

Another feature of interest is a small reproduction cutting in old growth hardwoods, where inferior old hardwoods were removed to secure white ash and basswood reproduction. Seedlings of these species are now coming in very well.

A large branch of the state nursery is maintained here, all of the Norway spruce and a large quantity of white pine being raised here from seed.

23. Just before reaching the village of South Royalton a side road to the east takes one to the farm of Hon. Amos J. Eaton. Here are two separate woodlots which have been judiciously thinned; one of white pine, the other of white birch. The latter is probably the best example of a well managed birch lot in the state. There are also some small plantations on a badly washed hillside.

24. The trip from the historic village of Royalton to Barre gives as fine an example of typical Vermont country side as one could find. Williamstown Gulf through which the road passes, is a very picturesque wooded defile.

25. On the north shore of Berlin Pond is an extensive plantation of white and Scotch pine made by the City of Montpelier to protect its watershed. This is the first and most extensive municipal forestry work yet undertaken in Vermont.

26. A few miles north of Montpelier, near the village of Putnamville, is one of the best managed hardwood forests in the state. This is a lot of about two hundred and fifty acres belonging to the C. C. Putnam & Son Lumber Company. The lower part of the lot is mostly of second growth maple, birch, poplar, white ash, etc., while farther up the slope there was considerable old spruce, hemlock and hardwoods. The owners have cut this lot during the last three years according to the advice of the Forestry Department. Most of the mature beech, poplar and hemlock has been cut, and considerable spruce and maple. Enough ash has been left to produce a large amount of seed and enough birch and maple to properly shade the ground. During the past three years 376,611 board feet of soft wood lumber and 299,000 feet of hardwoods have been removed and there is probably as much left and in better growing condition. This lot is well worth a visit.

27. Five miles south of Plainfield village is the L. R. Jones State Forest of six hundred acres, described elsewhere in this report. The principle things of interest are a second growth spruce stand about sixty years old which was thinned out four years ago and plantations at a high elevation of white and Scotch pines and Norway spruce. From a hill on this forest there is a splendid view of the whole Green Mountain range from Jay Peak to Killington.

28. Adjacent to the Montpelier and Wells River Railroad in the towns of Groton and Peacham, is one of the largest tracts of mismanaged forests in the state. There are about 10,000 acres here, next to worthless, because of

destructive lumbering followed by fire. If this had been properly lumbered it might easily be worth to-day $250,000.

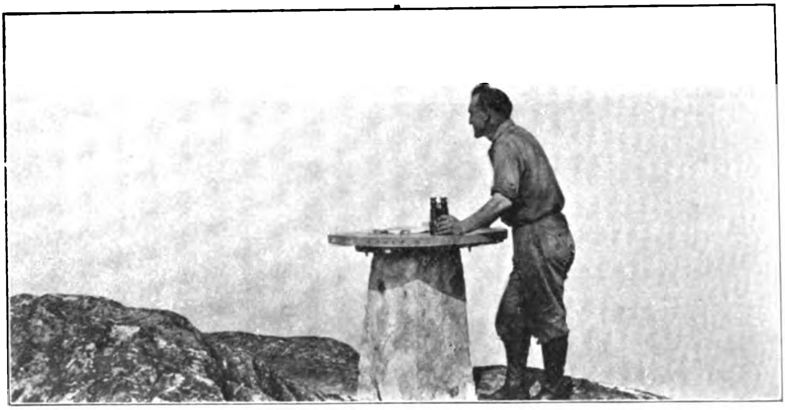
29. A white pine lot in Barnet owned by Mr. Wilbur Nelson is the best managed pine lot on the east side of the state. This pine, which is between forty and fifty years old, was thinned under the direction of the Forestry Department in the winter of 1914-15. The owner removed about 175,000 board feet of lumber and left the lot in splendid growing condition. Many of the largest trees as well as the more spindling ones were removed, the healthy, growing specimens being left. Looking down on this woodlot from the opposite slope very little seems to have been removed. In ten years the lot will probably be worth more than as if nothing had been cut.

30. In the town of Lyndon there is a rapidly growing area of bare sand which gives the town a rather desolate appearance from certain places. One of these areas just south of Red Village the State has purchased and reforested with Scotch and white pine. (See description elsewhere in this report). Besides these thriving plantations one should see here the sand fence built under the direction of the United States Department of Agriculture, as well as the brush fences; the sand binding grasses from Cape Cod and the plantings of willow cuttings about half of which are thriving on this bare sand.

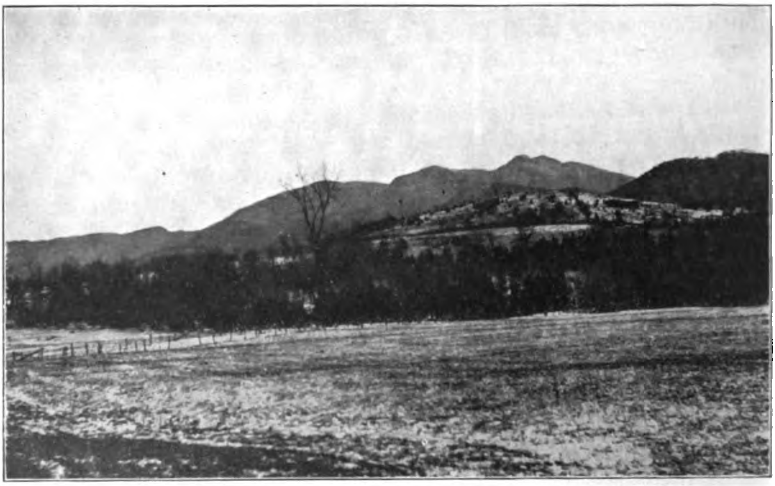
31. On the summit of Burke Mountain a few miles north of Lyndonville, is a fire lookout station and tower. This mountain, which stands out by itself, is very easily ascended and commands a wonderful view of all northern Vermont; the Green Mountains on the west and the Presidential range of the White Mountains to the east. To the north-east is the wild rolling forest region of Essex County, which should become a public forest before it is wholly destroyed by its present owners, as much of it already has been.

32. Willoughby Notch is an important feature of the landscape from Burke Mountain, and is only a few miles distant. This wonderfully beautiful little lake with the precipitous cliffs on either side is one of the scenic gems of eastern America. The good highway recently repaired makes it easily accessible.

33. Comparatively little interest in forestry has been taken in northern Vermont, but in the town of Enosburg is the most extensive private plantation in the state. This is on a farm owned by Dr. Wm. S. Stevens. He has planted, during the past six years, 250,000 trees, mostly white pine, but with a few small areas of Norway spruce. The older



LOOKOUT MAN AND CEMENT MAP STAND ON SUMMIT OF CAMEL'S HUMP



MOUNT MANSFIELD, THE HIGHEST MOUNTAIN IN VERMONT. ELEVATION 4364 FEET.

plantations are now making a good showing. The spruce here has done particularly well, the land being well adapted for it.

34. From Jeffersonville there is a road up into Smugglers' Notch, although the upper part of it is not at present passable for automobiles. One will be well repaid for the rather strenuous climb up through the Notch and on to the summit of Mansfield from Barnes Camp.

Smugglers' Notch is the wildest and most rugged bit of scenery in Vermont, and is fully equal to some of the better known notches of the White Mountains. Mansfield is the highest mountain in the state with an elevation of 4,364 feet. Its summit is a long ridge the profile of which is supposed to resemble a face, the different points being known as the forehead (furthest south); the nose (just above the mountain house); the chin (the most northerly high point); and the Adam's apple (somewhat below and north of this. There is a very extensive and beautiful view from the summit including most of northern Vermont, Lake Champlain and the Adirondacks. The mountain lies in a splendid forest belt, there being at least 30,000 acres in this immediate locality which should belong to the State. Just to the north is Sterling Mountain, while to the south is Bolton Mountain and Mount Admiral Clark, so named because the Admiral is in the habit of spending his summers at the beautiful little Lake Mansfield nearby.

35. One may descend the mountain on the west side starting down the Long Trail and crossing the Mansfield State Forest by the trail recently made by the Forestry Department. This is the largest state forest and is a tract of 3,000 acres. It was purchased for $3.25 an acre and would form a nucleus for a splendid state forest reserve. The only forestry work thus far done is at the south end of the tract and is described elsewhere in this report. The automobile can meet the climbers in the Stevens Brook valley in Underhill.

36. If possible Burlington should be entered by the way of Mallett's Bay. The drive along this Bay with the distant views of the Adirondacks and Green Mountains is one of the most beautiful water front drives in the eastern part of the country, and may be compared with some of the famous drives of Italy.

37. Burlington is the location of the state forest nursery, described elsewhere in this report. The demand for trees on the part of private owners is steadily increasing. The nursery is in three separate pieces. Most of the seed beds are in the Athletic field on Colchester Avenue; while

a large number of the transplants are in another field on the road east of the Green Mount Cemetery. Altogether there are about 3,500,000 trees in the Burlington nurseries, about one-third of which will be disposed of in the spring of 1916.

38. Just east of the state nursery is the pine forest of the University of Vermont, one of the best managed woodlots of the state. It is used for instructional and experimental purposes. A large amount of stumpage has been sold during the past few years but it has been cut in such a way as to improve the forest.

39. A mile or so east of Burlington, just off from Williston Road, is a sand plain owned by the University of Vermont. Several acres have been planted with forest trees, the most interesting part being an area planted in 1898 by Professor L. R. Jones. These white pines which were planted four feet apart, are now making a splendid height growth and are beginning to prune themselves. It is an excellent illustration of close planting.

REVIEW OF THE TOUR.

In outlining the above tour no attempt was made to visit the numerous forest plantations in the state, only a few of the more interesting being selected as examples. In the same way it was, of course, necessary to omit many places well known locally for their beauty. It is hoped that no one will feel slighted if his favorite mountain or lake is not included, since the writer did not include his own, Lake Memphremagog.

By climbing the six high mountains and two hills described above one will have obtained a bird's eye view of all of Vermont and much of the surrounding country. By visiting the forestry areas mentioned he will have a fair idea of the present forest practice of the State, since the worst and the best have been mentioned. In the course of the trip he will have seen scores of woodlots representing the average method, or lack of method, in handling.

FOREST PLANTING.

The spring of 1915 was, on the whole, favorable for forest planting. Although the latter part of May and the month of June were very dry, most of the trees had become established before this weather came on. Later in the summer there was an unusual amount of rain, so that many trees made a double growth.

The state nurseries at Burlington and Sharon have been enlarged to such a point that this year there was a surplus of about 350,000 white pines which were carried over to the age of four years.

Many former planters increased the plantations already made, and a great many new plantations were started. Altogether trees were furnished to 243 different parties, which is more than in any previous year.

In order to encourage small owners to experiment with forest planting, the Forestry Department offered a special package containing 250 three-year trees either white pine or Norway spruce. These packages were sent by parcel post, postage prepaid, upon the receipt of $2.00. Twelve of these packages of pine and five of spruce were sold.

The Vermont Forestry Association in the spring of 1914 made a special attempt to secure some demonstration plantings on conspicuous sites. The Association purchased from the state nursery two packages of 1,000 trees each to be placed in each county where land owners could be interested in planting such areas. The localities were selected by the county agricultural advisors, and in several counties the Extension Service of the University of Vermont and State Agricultural College cooperated with the Association in furnishing one or more packages. Sixteen thousand trees were thus placed in conspicuous sites where they will have an educational value in their communities in a few years.

Altogether somewhat over four million trees have been planted in Vermont during the first seven years after the establishment of the Forestry Department. Each of these plantations has its educational value which increases with age. The cumulative effect of all these demonstrations will, in a few years, be very noticeable. In itself this planting has covered nearly four thousand acres, an area which will be of great value at the end of forty or fifty years. Cultivated fields and planted forests are so much more productive than natural fields and forests, that it is difficult for many to appreciate the probable value of a mature forest plantation. A pine plantation forty years old will produce an average of 25,000 board feet per acre, and one fifty years at least 35,000 feet. The area already planted may, therefore, be expected to yield by 1955 about one hundred million board feet, or by 1965 nearly one hundred and forty million board feet. At $10.00 per thousand feet this means a stumpage value of $1,000,000, and $1,400,000 respectively. This estimated cut in 1965, if it were all placed on freight cars, would fill over 8,000 cars.

LIST OF TREES SOLD BY THE STATE NURSERY, 1915.

ADDISON COUNTY.

Bridport	H. D. Payne	200	black locust
Cornwall	Dr. Arthur W. Bingham	1,000	3 year white pine
Ferrisburg	C. A. Chapman	1,000	3 year white pine
Lincoln	E. S. Stevens	3,000	3 year white pine
Middlebury	Fred B. Mathews	250	3 year white pine
	C. L. Witherell,	500	3 year Norway spruce
	Miss Agnes Billings	5	3 year white pine
	(School package)	5	3 year Scotch pine
		5	3 year Norway pine
		5	3 year Norway spruce
		5	2 year white ash
		5,975	

BENNINGTON COUNTY.

Arlington	John R. Fisher	10,200	3 year white pine
	Mrs. F. W. Smith	1,000	3 year white pine
Bennington	Arthur J. Dewey	1,000	3 year white pine
		2,000	3 year Norway spruce
	H. C. McCullough	2,000	3 year white pine
	Albert W. Varney	500	2 year white pine
		500	2 year Scotch pine
Landgrove	*J. E. Thompson	1,000	3 year white pine
Manchester	George F. Wade	1,000	3 year white pine
Shaftsbury	Richard D. Currier	1,000	3 year Norway spruce
	Lake Shaftsbury Assoc.	1,000	3 year white pine
		1,000	3 year Scotch pine
		22,200	

CALEDONIA COUNTY.

Barnet	Wilbur Nelson	5,000	3 year white pine
Burke	A. D. Fogg	1,000	3 year white pine
	*A. F. Stoddard	1,000	3 year white pine
Danville	C. A. Joyce	5,000	3 year white pine
	R. B. Kinerson	2,000	3 year white pine
Hardwick	E. G. Bridgman	1,000	3 year white pine
Lyndon	Speedwell Farms	5,000	3 year white pine
Peacham	H. E. Farrow	250	3 year white pine
	J. P. Hutton	250	3 year white pine
		250	3 year Scotch pine
Ryegate	Peter M. Abbott	1,000	3 year white pine
St. Johnsbury	George W. Caldbeck	12,000	3 year white pine
	E. A. Gray	250	3 year white pine
	*Marcus J. Hovey	1,000	3 year white pine
		1,000	2 year white ash
		1,000	4 year Norway spruce
	J. B. Stanton	2,000	3 year white pine
	B. I. Grapes	5,000	3 year white pine
Walden	H. L. & F. H. Rogers	1,000	3 year white pine
Waterford	T. H. Lyster	1,000	3 year white pine
		46,000	

*Indicates a demonstration plantation made through the cooperation of the Vermont Forestry Association and the Extension Service.

CHITTENDEN COUNTY.

Burlington	Burlington Rendering Co.	3,000	3 year white pine
	H. G. Fuller	50	4 year white pine
	Gove Co.	1,000	3 year Norway spruce
	Rt. Rev. A. C. A. Hall	1,000	3 year Scotch pine
	W. H. Murdock	50	3 year white pine
	Robert Roberts	300	3 year Norway spruce
Charlotte	Genevieve C. Horsford	1,000	2 year white pine
Colchester	Dr. Daniel A. Shea	500	3 year Scotch pine
	F. B. Weston	2,000	3 year white pine
Jericho	*I. M. Nealy	1,000	3 year white pine
Underhill	Willard Pope	1,000	3 year white pine
		1,000	3 year Scotch pine
Williston	Frank Talcott	5,000	3 year white pine
		16,900	

ESSEX COUNTY.

Concord	Harry A. Ranney	2,000	3 year white pine
		1,000	3 year Norway spruce
		500	larch
		3,500	

FRANLIN COUNTY.

Enosburg	Dr. Wm. Stanford Stevens	50,000	3 year white pine
	J. C. Towle	250	3 year white pine
Fairfield	A. H. Fisher	3,000	3 year white pine
Georgia	Dr. Edmond J. Melville	500	3 year white pine
		500	3 year Scotch pine
Sheldon	*Rev. F. Banby Leach	1,000	3 year white pine
St. Albans	Hon. E. S. Brigham	500	4 year white pine
	A. H. Royce	5,000	3 year white pine
		60,750	

LAMOILLE COUNTY.

Johnson	Charles F. Hayford	500	3 year white pine
Morrisville	W. H. Boardman	1,000	3 year white pine
		1,500	

ORANGE COUNTY.

Chelsea	E. N. Bacon	1,000	2 year white pine
	R. H. Stanton	1,000	3 year white pine
	Stanley C. Wilson	2,000	3 year white pine
Fairlee	Camp Passumpsic	1,000	3 year white pine
	H. M. Miller	1,000	3 year white pine

Newbury	*George E. Chamberlin	1,000	3 year white pine
	J. W. Eastman	2,500	3 year white pine
Orange	Eugene R. Fellows	5,000	3 year Scotch pine
Randolph	George W. Flagg	3,000	3 year white pine
	Clark S. Hall	2,500	3 year white pine
	A. A. Priest	1,000	3 year Scotch pine
		1,000	3 year Norway pine
Strafford	William Munn	1,000	3 year white pine
	W. H. Robinson	2,500	3 year white pine
		500	3 year Scotch pine
	C. W. Sleeper	1,000	3 year white pine
		1,000	3 year Scotch pine
Thetford	C. A. Adams	500	3 year white pine
	C. C. Cook	250	3 year Scotch pine
	Clarence K. Horsford	5,000	2 year white pine
	Arthur Palmer	1,000	2 year white ash
	*Arthur Palmer	1,000	3 year white pine
	Miss Christine Vaughan	2,000	3 year white pine
Williamstown	F. A. George	3,000	3 year white pine
	Mrs. Martha E. Wales	3,600	3 year white pine
		44,350	

ORLEANS COUNTY.

Barton	J. F. Batchelder	500	3 year white pine
	A. G. Fletcher	20	3 year white pine
	(School Package)	20	3 year Norway spruce
		20	3 year Scotch pine
		20	3 year Norway pine
		20	3 year white ash
	Walter H. Gilpin	250	3 year white pine
	A. A. Hawkins	2,000	3 year white pine
	O. W. Locke	1,000	3 year white pine
	Miss Lius J. Winslow	5	3 year white pine
	(School Package)	5	3 year Scotch pine
		5	3 year Norway pine
		5	3 year Norway spruce
		5	2 year white ash
Brownington	Wilmer H. Gray	1,000	3 year white pine
Glover	*John Mathie	1,200	3 year white pine
	L. R. Young	2,000	3 year white pine
Greensboro	E. L. Esdon	1,000	3 year white pine
	Mrs. Herbert Turrell	2,000	3 year white pine
Newport	Sydney F. Davis	250	3 year white pine
	*C. W. Richmond	1,000	3 year white pine
		12,325	

RUTLAND COUNTY.

Castleton	*C. A. Beach	1,000	3 year white pine
	*P. F. Burke	1,000	3 year white pine
	J. S. Dean	250	3 year Norway spruce
	Philip Leavenworth	250	3 year white pine
Pawlet	Will G. Rogers	250	3 year Norway spruce
Pittsford	Vermont Sanatorium	10,000	3 year white pine

Proctor	Miss Emily Dutton	4,300	4 year white pine
	Proctor	3,700	3 year white pine
West Rutland	Charles H. Campbell	250	3 year white pine
		21,000	

WASHINGTON COUNTY.

Barre	City of B. Cemetery Department	1,000	3 year white pine
		1,000	3 year Norway pine
		200	3 year Norway spruce
	City of B. Park Dept.	1,000	3 year white pine
		1,000	3 year Norway pine
	A. B. Lane	1,000	2 year white pine
	D. A. Perry	2,000	3 year white pine
Berlin	T. D. Hobart	5,000	3 year white pine
		1,000	3 year Scotch pine
		1,000	3 year Norway pine
		2,000	3 year Norway spruce
		500	2 year white ash
Cabot	L. C. Fisher	10,000	3 year white pine
Calais	Henry Holt	10,000	3 year white pine
	L. A. Keniston	2,000	3 year white pine
	Ira Rich Kent	3,000	3 year white pine
	S. Rich Waite	1,000	3 year white pine
East Montpelier	O. L. Tillotson	1,000	3 year white pine
Middlesex	Ralph Putnam	4,000	2 year white ash
		10,000	3 year white pine
Moretown	Kelty Bros.	2,000	3 year white pine
	Ward Lumber Company	2,000	3 year Norway spruce
Plainfield	William T. Dunn	1,000	3 year white pine
Waitsfield	Richardson Bros.	7,500	3 year white pine
	Walter H. Moriarty	3,000	3 year white pine
Warren	H. W. Brooks	1,000	3 year white pine
	J. W. Mobus	1,000	3 year white pine
Waterbury	J. E. Greene	3,000	3 year white pine
	Wilder Thomas	1,000	3 year Norway spruce
	Alton G. Wheeler	1,000	3 year white pine
		80,200	

WINDHAM COUNTY.

Brattleboro	Abbott & Barber	1,000	3 year white pine
		500	2 year white ash
	Estey Organ Company	1,000	3 year white pine
		2,000	2 year white ash
	O. L. French	250	3 year Norway spruce
		250	white spruce
	J. M. Johnson, Jr.	10,000	3 year white pine
	*A. W. Sweeton	1,000	3 year white pine
Dummerston	D. R. Miller	1,000	locust
Grafton	L. Daniels	250	3 year Norway spruce
	Geo. W. Hall	1,000	2 year white pine
Guilford	E. F. Evans & Son	1,000	3 year white pine
Jamaica	Leon W. Cheney	1,000	3 year white pine

Londonderry	William Aldrich	1,000	3 year white pine
	Williams Bros.	20,000	3 year white pine
Marlboro	B. M. Whitacre	2,000	3 year white pine
Newfane	M. B. Martin	1,000	3 year white pine
Putney	H. W. Goodsell,	1,000	3 year white pine
	C. E. Prouty	1,000	2 year white pine
Rockingham	*Harry Barnes	1,000	3 year white pine
	D. M. Damon	5,000	3 year white pine
	Mrs. Edgar Guild	250	3 year Norway spruce
	*Lewis C. Lovell	1,000	3 year white pine
	Frank W. Morrison	1,000	3 year white pine
	W. C. Putnam	250	3 year white pine
	H. A. Stoddard	1,500	3 year white pine
Townshend	D. S. Brownell	1,000	3 year white pine
	F. T. Randall	100	3 year Norway pine
		100	2 year white ash
Vernon	Johnson Bros.	2,000	3 year white pine
Westminster	Harry A. Barnes	1,000	3 year Norway pine
Wilmington	M. A. Brown	500	3 year white pine
	Mr. May	1,000	3 year white pine
		61,950	

WINDSOR COUNTY.

Bethel	Guy Wilson	1,430	4 year white pine
	Paul Wilson	250	3 year white pine
Bridgewater	B. F. Weeden	300	3 year Norway spruce
Cavendish	Miss Fanny B. Fletcher	1,000	3 year white pine
	Gay Bros. Co.	1,000	3 year white pine
Chester	Vermont Marble Co.	20,000	3 year white pine
		10,000	4 year Norway spruce
Hartford	A. P. Clifford	2,000	3 year white pine
	Quechee Fells Farm	1,000	3 year white pine
Ludlow	E. C. Carpenter	500	3 year white pine
Norwich	J. L. Hazen	2,000	3 year white pine
Pomfret	E. Y. Dana	2,000	3 year white pine
	Walter E. Perkins	250	3 year white pine
Royalton	Citizens Water Co	5,000	3 year white pine
	Dr. D. E. Dearing	1,000	3 year white pine
	A. C. Gibson	3,000	3 year white pine
	*Leon A. Skinner	1,000	3 year white pine
		250	3 year Scotch pine
Sharon	Church Men's Club	29,625	3 year white pine
	H. E. Day,	1,000	3 year white pine
	A. B. Finney	1,000	3 year white pine
	William E. Heath	2,000	3 year white pine
	John Killoran	100	3 year white pine
		100	3 year Norway spruce
	Don E. Moore	2,000	3 year white pine
	H. W. Moore	2,000	3 year white pine
	W. W. Keyler	2,000	3 year white pine
	J. J. Parker	500	3 year white pine
	W. C. Porter	29,000	3 year white pine
	F. W. Welch	2,000	3 year white pine
Springfield	Miss Lena A. Britton	250	3 year white pine
	Harold Graham	500	3 year white pine
	Ralph Olney	500	3 year white pine

	Springfield Village	10,000	3 year white pine
	A. K. von Arnim	250	3 year white pine
	P. H. Whitney	1,000	2 year white pine
Weathersfield	C. F. Aldrich	1,000	3 year white pine
	John H. Hicks	2,500	3 year white pine
	Mrs. Leavitt Hunt,	50	3 year white pine
	J. A. Woodbury	1,000	2 year white pine
	Miss Mary U. Woodbury	1,000	2 year white pine
West Windsor	E. D. Sawin	2,000	3 year white pine
	George G. Waite	4,000	3 year white pine
Woodstock	James D. Atkin	250	3 year white pine
		250	3 year Norway spruce
	Herbert W. Daniels	3,000	3 year white pine
	E. A. Fullerton	1,000	3 year white pine
	Wales N. Johnson	500	3 year white pine
	W. E. Mack	500	3 year white pine
	Richard M. Marble	6,000	3 year Norway pine
	A. L. Powers	4,000	3 year Norway pine
		162,855	

SUMMARY OF TREES PLANTED IN 1915 BY COUNTIES.

Addison	County	....Private planting	5,975	
Bennington	"	....Private planting	22,200	
Caledonia	"	....Private planting	46,000	
"	"	....State planting	5,000	✓
Chittenden	"	....Private planting	16,900	✓
"	"	....State planting	45,000	
Essex	"	....Private planting	3,500	
Franklin	"	....Private planting	60,750	
Lamoille	"	....Private planting	1,500	
Orange	"	....Private planting	44,350	
Orleans	"	....Private planting	12,325	
Rutland	"	....Private planting	21,000	
"	"	....State planting	75,000	✓
Washington	"	....Private planting	80,200	
"	"	....State planting	200,000	✓
Windham	"	....Private planting	61,950	✓
"	"	....State planting	32,000	
Windsor	"	....Private planting	162,855	✓
"	"	....State planting	95,000	
			*991,505	

*In addition to the above it should be stated that the Executors of the Joseph Battell Estate planted approximately 100,000 trees raised by the Botany Department of Middlebury College, and Mr. George Chedel sold about 30,000 trees to Vermont planters, so that about 1,100,000 trees were planted in the state.

THE STATE FOREST NURSERY, BURLINGTON.

This nursery has been continued at about the same capacity as in recent years. In the spring of 1915 there was sown 200 pounds of white pine and 8 pounds of Scotch pine seed, but owing to the fact that part of the seed was a year and a half old the stand of seedlings obtained was no greater than in the previous year, when less seed was used.

INVENTORY OF STATE NURSERY.

JULY 1, 1915.

(Ages given are for the end of the growing season of 1915).

White pine	4	year transplants	290,000	
" "	3	" "	800,000	
" "	2	" seedlings	1,790,000	
				2,880,000
Scotch pine	3	year transplants (Riga variety)	70,000	
" "	2	" seedlings	25,000	
				95,000
Red pine	3	year transplants	65,000	
" "	2	" seedlings	290,000	
				355,000
Norway spruce	3	year transplants	40,000	
				40,000
Red spruce	3	year transplants	30,000	
				30,000
White spruce	3	year transplants	6,000	
" "	2	" seedlings	14,000	
				20,000
Balsam	3	year transplants	15,000	
				15,000
Arborvitae	3	year transplants	60,000	
"	2	" seedlings	35,000	
				95,000
European Larch	3	year seedlings	5,000	
				5,000
White Ash	3	year transplants	14,000	
				14,000
				3,549,000

VERMONT STATE FORESTS.

The people of Vermont are beginning to take an active interest in their state forests, of which there are now twelve in as many sections of the State. The purposes of these forests may be briefly summarized as follows:

1. To furnish local demonstrations to increase the general practice of forestry.
2. To furnish places for careful experimentation and

study to secure information which will be available for the general public.

3. To grow lumber, especially of the larger sizes, and wood which will eventually be valuable to local industries.

4. To derive an income for the state from land which would otherwise be of little value.

5. To protect the local water supply and improve the scenery.

The Forestry Department wishes the state forests to be of the greatest possible use to the people of the localities in which they are located. Wood and lumber will be sold at the market price from most of the forests whenever cuttings seem desirable. In certain cases dead wood and other material of little value will be given to deserving people if they will remove it under rules of the Department in such a way as to improve the remaining stand. Under special conditions also camp sites may be rented in the forests.

In purchasing forests no tracts of less than 500 acres will be considered unless they present problems of special interest. No tracts, which have been lumbered clean and subsequently burned over during the past fifteen years, will be considered unless accompanied by some land of better quality. All lands will be appraised, not only for the standing timber upon them, but for the young growth and the character of the soil.

CHARLES DOWNER FOREST.

This forest is becoming more and more a place of interest for people in the surrounding region. Many parties from the neighboring towns visit the nursery and plantations during the course of the summer. The Sharon Day Picnic, which has become a regular institution, was well attended in 1914. Addresses were made by Professor Thomas Bradlee, in charge of agricultural extension work; Mr. Coryell; Mr. James P. Taylor, Secretary of the Greater Vermont Association, and Mr. Amos J. Eaton.

Several acres of swamp were underdrained during the summer of 1914, in cooperation with Mr. Downer, and some of the land formerly drained is now used for nursery.

No forestry cuttings have been made during the year because of unfavorable conditions.

This forest was unfortunate in having the first forest fires which have occurred on any of the state forests since their ownership by the State. Two fires occurred in the early spring of 1915. One was due to the carelessness of employees in burning brush, and the other was apparently started by a tramp. A small portion of the plantation set in 1909 by Mr. Downer was destroyed by the first fire.

In the spring of 1915 there were planted near the south end of the tract 50,000 three year white pines, and 30,000 three year Norway spruce.

SUMMARY OF TREES PLANTED 1910 TO 1915 (INCLUSIVE.)

Species.	No. Planted.
White pine,	106,000
Red pine,	22,700
Scotch pine,	19,000
Austrian pine,	2,400
Norway spruce,	54,000
Colorado Blue spruce,	100
Red fir,	5,000
Arborvitae,	1,000
Black locust,	3,000
European larch,	4,000
White ash, .	15,000
	232,200

The branch of the state nursery has been continued on this forest and has been more successful than in previous years. Little damage was done during the past year by grubs and practically none by birds. There was sown in the spring of 1915; 50 pounds white pine and 15 pounds Norway spruce seed.

INVENTORY OF NURSERY JULY 1, 1915.

(Ages given are for the end of the growing season of 1915.)

White pine 3 year transplants,	490,000	
White pine 4 year transplants,	5,000	
White pine 2 year seedlings,	550,000	
		1,045,000
Norway spruce 4 year transplants,	6,000	
Norway spruce 3 year transplants,	235,000	
Norway spruce 2 year transplants,	300,000	
		541,000
Eureopean larch 3 year transplants,	7,000	
		7,000
Red spruce 4 year transplants,	4,000	
		4,000
		1,597,000

FINANCIAL STATEMENT JULY 1, 1915.

CREDIT DOWNER STATE FOREST.

Nursery stock and refund on planting,	$ 702.38
Produce sold and refund for horse training,	326.00
Wood sold,	57.97
Building sold,	15.00
Credit for trees furnished Proctor-Piper Tract,	75.00
Credit for trees furnished Mansfield Forest,	100.00
Credit for trees furnished L. R. Jones Forest,	250.00
	$1,526.35

EXPENDITURES.

Superintendent's Salary,	$ 660.00
Superintendent's Expenses,	169.61
Labor,	2,135.76
Miscellaneous supplies,	447.63
	$3,413.00

L. R. JONES FOREST—PLAINFIELD.

The most extensive single planting operation thus far carried on was done on this forest in the spring of 1915, practically completing the planting of the open land on this tract. The following species were planted:

White pine	3 year transplants,	80,500
Norway pine	3 year transplants,	4,500
Norway spruce	3 year transplants,	25,000
		110,000

The spruce and 25,000 of the white pine were raised in the Sharon nursery; the remaining white pine in the Burlington nursery.

In cooperation with the Agricultural Experiment Station two sets of permanent sample plots were established on this forest, one in the spruce and the other in the white birch type. The variety of the growth and the opportunity of pursuing a definite policy fôr a long term of years makes this forest one of the best for the study of important forest problems.

As shown in the last annual report, the total estimate for this forest in 1914 was 1,500,000 board feet, and 1,900 cords of wood.

BATTELL FOREST, CAMEL'S HUMP PARK—DUXBURY AND HUNTINGTON.

Elsewhere in this report mention is made of the two splendid bequests made by the late Col. Battell to Middlebury College and the United States Government respectively. This tract on Camel's Hump, given by Col. Battell to the State, is probably our most valuable state forest, and the one which is the most largely visited. The Forestry Department has laid out a new trail connecting Honey Hollow and Jonesville with the Huntington trail, and in cooperation with the Camel's Hump Club has considerably improved the new trail up from Duxbury.

The plantations of pine set on this forest in 1913 have been considerably damaged by the browsing of deer. In other places also it has been found that the deer particularly take to pine when it is planted in localities where they are not used to it. The spruce plantings, on the other hand, have been practically uninjured. For this reason an extensive planting of Norway spruce was made in the spring of 1915. 90,000 four year transplants were set out on the old burn of 1903. Since this area is two or three miles from the nearest houses, and a hard climb from them, it was necessary to camp the men while planting. Two large camps were maintained at an elevation of about 2,000 feet. The trees were taken to the planting site by ox teams which alone can traverse these rough mountain roads.

With this extensive plantation in such an exposed situation it became desirable to furnish special protection. A fire line has, therefore, been constructed along the northern edge of the plantation, by removing all inflammable material on a strip about a rod wide. This would furnish an excellent place to make a stand against a fire.

As stated in the last report, the estimated stand on this forest was 7,000,000 board feet in 1914. It was found, however, that the State's title to one lot was of little value, and an agreement was, therefore, made whereby the Ward Lumber Company quit-claimed their right to the land after removing the timber. This cutting is now nearly completed. It will not, however, materially reduce the total estimate.

HAULING SPRUCE SEEDLINGS BY OX CART UP TO THE BURNED LAND ON CAMEL'S HUMP.

CAMP OF THE FOREST PLANTING CREW ON CAMEL'S HUMP STATE FOREST.
SPRING 1915

LYNDON SAND FOREST PLANTATION.

Perhaps none of the state forests have done more in an educational way than this one. At the time the Forestry Department began planting this barren sand there was a noticeable feeling of scepticism on the part of the people as to whether trees would grow on such an unfavorable site. It has now been amply demonstrated that the Scotch pine will thrive on these soils. The plantation is now conspicuous from the B. & M. R. R. on the east of the track, just below Lyndon station. During the past spring the third annual meeting of fire wardens was held on this tract. About seventy wardens were the guests of Mr. C. M. Darling, the local warden, who has generously furnished transportation and dinners for the party for the past three seasons. Those who had attended previous meetings were surprised to note the growth of the trees during the year.

The greatest problem at Lyndon, however, still remains to be solved. This is the checking of the main sand wave, which covers over ten acres and is over twenty feet in height. Trees cannot gain a footing on this wave because the sand is shifting so rapidly. The problem is, therefore, to stop the drifting of the sand long enough to allow the trees to gain a rooting. This has been one of the most difficult problems in the history of forestry, but one which has been successfully met in France and elsewhere. The velocity of the advance of sand dunes was estimated by Bremontier*, the great engineer, at the end of the 18th century, at sixty to seventy-five feet a year. A church at Lege was rebuilt in 1480 at two and one-half miles from its original position, which had been buried. In 1650 it had to be moved again two miles further inland, corresponding to an annual average progress of about sixty feet. In 1780 a basilica of Soulac was entirely buried by a hill of sand the height of which was more than sixty feet at the place of the steeple. In 1801 the dune had progressed so far that it had uncovered the top of the steeple which was used as a beacon. Toward the middle of the 19th century the dune had moved so far that the roof of the church emerged from its long hiding place. Thousands of acres of such sand dunes have been successfully reforested by the French Government during the past half century. In our own country the most extensive sand dunes are those of the Columbia river of the north west. The United States Department of Agriculture has experimented thoroughly with various devices for stopping these dunes. The difficulty is that permanent fences or obstacles are soon buried like the church above described. The greatest success has been obtained by a temporary loose board fence, and we have accordingly followed this policy at Lyndon. A fence is made of separate sections, each about ten feet long. Boards are nailed about four inches apart to uprights. The sections are then placed end to end on top of the same dune at the edge of the steep slope. The sand blows through the spaces between the boards and piles up just beyond the fence. As soon as it has piled up a few feet the fence is raised and relocated on the new brink. In this way the dune becomes higher and higher instead of advancing. Many trees which were partially covered by the front of the dune when the fence was built in April 1915 were entirely uncovered in July. The theory is that the dune will finally become so high and its sides will be so steep that the sand will not blow over and it will become stationery. When this occurs it can be successfully reforested.

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*See "Economie Forestiere," par G. Huffel. Vol. 1.

At the suggestion of Governor Gates these loose board fences have been supplemented by brush fences built on the more level places. These have been found valuable by the State Highway Department in checking drifting sand on the plains at Georgia, Vermont. Hon. T. N. Vail kindly allowed the brush to be cut from his farm nearby.

There was planted on this area, during the spring of 1915, 3,000 3 year white pine, and in the fall 2,000 3 year Scotch pine in places where previously planted trees had died.

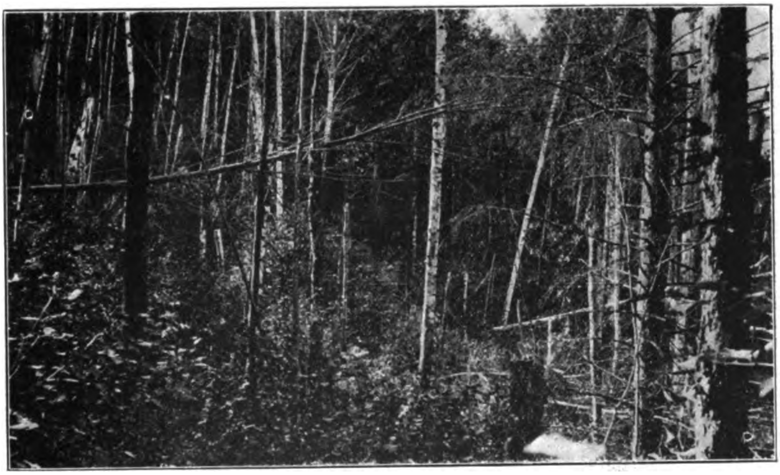
SUMMARY OF PLANTING 1912 TO 1915 (INCLUSIVE.)

Scotch pine,	79,000
White pine,	38,600
Norway spruce,	3,000
Western yellow pine,	1,300
Pitch pine,	50
European larch,	200
	122,150

GEORGE AITKEN FOREST—MENDON.

Some of the old wood roads in this forest have been cleared out to serve as fire lines. The growth on inferior areas has been sold standing @ $10.00 an acre. After cutting, all tops were burned and the land was then replanted

HEAVY STAND OLD GROWTH HEMLOCK
ROCHESTER, VERMONT.



POOR QUALITY HARD WOODS ON GEO. AITKEN STATE FOREST. THIS IS TO BE CUT CLEAN AND PLANTED WITH PINE.

with 15,000 white pine from the Burlington nusery and 10,000 3 year Norway spruce from Randolph, Vt.

SUMMARY OF TREES PLANTED 1913, 1914, 1915.

White pine,	34,000
Scotch pine,	6,000
Red or Norway pine,	3,000
Norway spruce,	20,000
Varieties of spruce,	500
White ash,	800
Red oak,	1,000
	65,300

In examining these plantations in the fall of 1914 the writer had difficulty in finding the trees because of the dense mat of goldenrod and other growth. It seemed that comparatively few of the trees had lived. When re-examined in the spring of 1915, when the herbacious growth was dead, fully eighty per cent of the trees planted in 1913 appeared to be alive and doing well, except that the leaders of many of the Scotch pine had been browsed by deer.

The detailed estimate of the growth on this forest was given in the report of 1913, and was 320,000 board feet and 4,855 cords of wood. Since the growth on the forest will more than compensate for what has been cut during the past two years, it is safe to say that there is now at least 5,000 cords of wood in addition to the lumber mentioned above. This tract offers perhaps the best opportunity for the practice of forestry of any of the state forests because of its proximity to Rutland and the excellent market for wood there.

WEST RIVER FOREST—TOWNSHEND.

The temporary nursery established in connection with this forest last year was used to supply trees for planting this spring and was then discontinued as was originally planned. Besides 8,000 3 year white pine and 24,000 3 year red pine planted on the forest, the remaining stock was sold to people in the West River Valley, who had become interested in forestry largely because of the demonstration here.

SUMMARY OF TREES PLANTED IN 1913 AND 1915.

White pine,	21,000
Scotch pine,	12,000
Red pine,	24,000
European larch,	1,000
	58,000

The estimate of this forest as given in the last report is 4,000 cords. Since no wood has been cut in the meantime the stand is now somewhat greater.

In cooperation with the Agricultural Experiment Station some permanent sample plots were laid out in this forest for the study of natural reproduction.

A study of the growth of this forest has now been completed. The annual growth of the various species is as follows:

Spruce,	17.	cords
Birch,	9.	"
Maple,	10.	"
Ash,	1.	"
Yellow Birch,	25.	"
White Birch,	15.	"
Basswood,	4.	"
Hemlock,	30.	"
White Pine,	4.	"
	115.	"

As mentioned in the previous report, this forest not only furnishes an excellent opportunity for the demonstration of forestry methods, but provides a notable example of the over-taxation of cut-over woodlands as practiced in many towns of the State. This forest is estimated to contain 4,000 cords of wood, of which only a small part is fit for lumber. The annual growth of the forest has now been carefully ascertained to be 115 cords, or 2.8% of the total. This is the growth made by the forest previous to the application of forestry principles. Cordwood on this forest is scarcely worth sixty cents a cord, but at that price the growth would correspond to an annual income of $69. The tax on this property in 1915 is $90.30, showing a net loss, not including interest on the investment of $21.30.

This information is given not so much in criticism of the taxation of this state forest, as an illustration of the evils of the present method of taxation. Hundreds of woodlots in the State, if carefully studied in this way, would be found to be producing less than enough to pay the taxes. That the State in this case is attempting to increase the growth, and will in time accomplish this result, should not be a reason to overtax the tract, but should rather influence the listers in the other direction.

ARLINGTON FOREST.

No new work has been done on this forest. In the summer of 1914 a forest conference was held here in cooperation with Mr. Sherman, the County Agricultural advisor. There was a good attendance of local people who were much interested in the progress shown by the plantations.

As estimated in 1913, this tract has 2,100 chestnut ties 2,300 cords of wood.

WEST RUTLAND FOREST.

In cooperation with the Experiment Station, two sets of experimental plots were established on this forest. One very interesting type here is a stand of red oak and white birch in mixture. The former a southern species and the latter a northern tree are rarely found together. Under these is an excellent stand of spruce reproduction. One of the experiments is to ascertain the reproduction which will follow a cutting in this type.

The advisability of fall planting is a question that has been much discussed by foresters and others. In order to obtain more accurate information on this subject planting was done in the fall of 1914 and 1915. The trees planted in the fall of 1914: 20,000 3 year white pine and 5,000 European larch, suffered severely from an early frost in September. In early September 1915, 25,000 4 year white pine transplants from the Burlington nursery were planted. The summary of all the trees planted on this forest is as follows:

White pine,	4 year transplants	35,000
White pine,	3 year transplants	24,000
Red pine,	3 year transplants	10,000
Norway spruce,	3 year transplants	5,000
European larch,	3 year transplants	5,000
		79,000

Following the policy which has been laid down for all the state forests, the growth of this forest was accurately determined and is given in the following table. It will be seen that on the whole the forest is making a very favorable growth, especially the poplar, yellow and white birch.

SUMMARY OF THE GROWTH OF THE WEST RUTLAND FOREST.

Species	Present Stand		Percent annual vol. growth	Annual Growth	
	Bd. Ft.	Additional cords		Bd. Ft.	Addition-cords.
Spruce	10,000	200	3.7	370.	7.4
Oak	90,000	200	3.0	2,700.	6.
Basswood	90,000	....	2.5	2,100.	3.4
Ash	20,000	150	2.3	450.	3.5
Maple	150,000	300	3.8	5,700.	11.5
Yellow Birch	40,000	80	5.2	2,080.	4.1
Poplar		170	9.4		15.9
Beech & Others		400	3.7		14.8
White Birch		800	4.7		37.6
Totals	400,000	2,300		13,400	104.2

MANSFIELD FOREST.

Soon after the purchase of this tract (the largest of the state forests) as described in the report of 1914, a surveying and estimating crew was established in the forest. This crew, consisting of four men, first camped on the Stevens Brook in the northern part of the tract and later on the Lee River in the southern part. The boundaries were carefully resurveyed and strips four rods wide were run across the tract in an east and west direction forty rods apart. All trees on these strips down to seven inches in diameter were measured so that ten per cent. of all trees over this diameter on the tract were measured.

The first thing to be done in the organization of any large forest is its division into convenient working areas. Since in a mountainous country the watershed controls the marketing of the produce the Vermont Forestry Department has established the policy of dividing the state forests into blocks corresponding to the principle watersheds. In the Mansfield Forest there are three blocks as follows, commencing at the north:

Stevens Brook block,	1,282.	acres
Clay Brook block,	510.	"
Lee River block,	1,363.	"
Total area,	3,155.	"

Each block is again subdivided, according to the character of the forest, into compartments varying in size, in this forest, from forty to four hundred and fifty acres. The following stand table gives the estimated amount of lumber for each compartment. It must be remembered that the tract was culled over about twenty-five years ago and that the lumber is, therefore, of rather poor quality, and furthermore that it is widely scattered as is readily seen from the fact that the average stand is only 2,800 board feet per acre.

MANSFIELD FOREST SUMMARY OF STAND BY BLOCK & COMPARTMENT.

Block	Compartment No.	Volume by Species in bd. ft.									
		Spruce	Balsam	Yellow Birch.	Hard Maple.	Beech	Ash	White Birch.	Hemlock	Others	Total Vol. of Compartment.
Lee River............	I	365,000	322,000	90,000	2,000	4,000	......	38,000	......	3,000	824,000
	II	101,000	18,000	50,000	20,000	18,000	......	2,000	1,000	4,000	214,000
	III	472,000	7,000	400,000	500,000	340,000	79,000	50,000	23,000	12,000	1,883,000
	IV	....	....	....	....	....	......	....	......	......	....
Clay Brook	I	225,000	37,000	270,000	170,000	140,000	1,000	1,000	13,000	1,000	858,000
	II	....	....	....	....	....	......	....	......	......	....
	III	16,000	1,000	8,000	4,000	3,000	......	....	......	1,000	33,000
	IV	177,000	1,000	140,000	150,000	60,000	1,000	3,000	6,000	1,000	539,000
Stevens' Brook	I	129,000	2,000	130,000	140,000	50,000	1,000	6,000	6,000	1,000	465,000
	II	....	....	....	....	....	......	....	......	......	
	III	200,000	95,000	60,000	30,000	8,000	......	8,000	4,000	1,000	406,000
	IV	446,000	24,000	310,000	90,000	40,000	......	43,000	4,000	2,000	959,000
	V	89,000	13,000	45,000	15,000	8,000	......	4,000	2,000	1,000	178,000
	VI	219,000	1,000	250,000	310,000	180,000	1,000	10,000	16,000	4,000	991,000
	VII	78,000	2,000	110,000	35,000	50,000	1,000	....	2,000	1,000	279,000
	VIII	139,000	5,000	115,000	65,000	25,000	1,000	11,000	2,000	1,000	364,000
Totals.		2,656,000	528,000	1,978,000	1,531,000	926,000	85,000	176,000	79,000	33,000	7,993,000

The open land of Compartment IV of the Lee River block was planted in the spring of 1915 with the following:

25,000	3 year white pine from the Burlington nursery,
20,000	3 year Norway spruce from the Sharon nursery
45,000	

This tract is so inaccessible for local labor that the planting was done chiefly with men brought from Burlington. A camp was maintained on the Lee River throughout the planting work.

The cost of this planting was as follows:

Labor and cartage of trees,	$110.00
R. R. transportation of men,	10.00
Food,	35.00
Cost of stock,	225.00
	$380.00
Average cost per M.,	$ 8.50

This forest furnishes an excellent example of the over-assessment of cut-over forest lands, it having been assessed since 1910 at $10,500. although the State purchased it in 1914 for $9,500.

PUTNAM FOREST.*

In the fall of 1914 Mr. C. C. Putnam and Mr. Ralph Putnam of Middlesex gave to the State a tract of 1,100 acres in the town of Worcester in Washington County. This area lies on the east side of the Mount Hunger mountain range, which is east of the main Green Mountain range. The slopes were lumbered by the Putnam Company several years ago and were subsequently burned over in the bad season of 1903 before the organization of the forest fire service. While there is little of value on this forest at present, it is an excellent tract for the State to hold and on which to demonstrate what can be done with this kind of land, of which there are so many thousand acres in Vermont.

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*A portion of this land was bought by Messrs. Putnam at a tax sale. The State reimbursed them for this slight expenditure.

PROCTOR-PIPER FOREST TRACT.

In the fall of 1914 Mr. Redfield Proctor of Proctor gave to the State a tract of about 400 acres in the town of Cavendish. This very interesting forest is only a short distance from the Proctorsville station and is, therefore, excellently located for demonstration purposes. It is to be known as the Proctor-Piper Forest Tract in memory of the late Senator Proctor and his friend Mr. Piper who once owned the tract together. The only condition made in this very generous gift is that included in the following paragraph of the deed:

"Provided, however, and this conveyance is upon the express condition, that if the Forestry Department of the State of Vermont shall at any time hereafter cease to exist, or if for a period of five years the State shall neglect to maintain the lands hereby granted and conveyed as a state forest, and for the purposes hereinafter set forth, then this conveyance shall be and remain null and void, and the title to the lands hereby granted and conveyed shall revert to and become revested in this grantor and his legal heirs."

In the spring of 1915 the following trees were planted on the open parts of this tract.

5,000	white pine	3	year	transplants	from	Sharon
9,300	Norway spruce	4	"	"	"	"

Much of the land was covered with brush making planting rather difficult and expensive. The total cost was $80.46, or an average og $5.70 per thousand trees.

This forest has been carefully estimated and mapped. The results are shown in the following table.

BROOK ON THE PROCTOR-PIPER FOREST TRACK.

LOG CABIN GIVEN TO THE STATE WITH PROCTOR-PIPER FOREST TRACT.

PROCTOR-PIPER FOREST TRACT. SUMMARY OF STAND.

Com-partment	Stand	White Pine	Spruce	Yellow Birch	Hard Maple	Beach	Ash	Bass-wood	White Birch	Hemlock	Others	Total
		Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.
I	A	40,000	20,000	15,000	20,000	15,000	10,000	5,000	15,000	25,000	10,000	175,000
II	A		20,000	10,000	15,000	10,000			15,000	25,000	10,000	105,000
Total,		40,000	40,000	25,000	35,000	25,000	10,000	5,000	30,000	50,000	20,000	280,000
		Cords	Cords	Cords	Cords	Cords	Cords	Cords	Cords	Cords	Cords	Cords
				320	580	190	530	130	850		400	3,000

Total stand of the forest 280,000 bd. ft. plus 3,000 Cords of Wood.

SUMMARY OF TREES PLANTED ON STATE FORESTS IN 1915.

Caledonia County,	Lyndon,	3,000 3 year white pine	
		2,000 3 year Scotch pine	5,000
Chittenden County,	Underhill,	25,000 3 year white pine	
		20,000 3 year Norway spruce	45,000
Rutland County,	Mendon,	15,000 3 year white pine	
		10,000 3 year Norway spruce	25,000
" "	West Rutland,	20,000 3 year white pine †	
		25,000 4 year white pine	
		5,000 European larch †	50,000
Washington County,	Plainfield,	80,500 3 year white pine	
		4,500 3 year Norway pine	
		25,000 3 year Norway spruce	110,000
" "	Duxbury,	90,000 4 year Norway spruce	90,000
Windsor County,	Cavendish,	5,000 3 year white pine	
		10,000 3 year Norway spruce	15,000
" "	Sharon,	50,000 3 year white pine	
		30,000 3 year Norway spruce	80,000
Windham County,	Townshend,	8,000 3 year white pine	
		24,000 3 year red pine	32,000
			452,000

APPROXIMATE AREA AND STAND OF STATE FORESTS.

		Total Stand.		
Name.	Area Acres.	Board Feet.	Ties.	Cords.
Chas. Downer Forest,	800	*		
L. R. Jones Forest,	600	1,500,000		1,900
M. J. Hapgood Forest,**	100	*		
Battell Forest,	1,200	7,000,000		
Lyndon Plantation,	75	0		0
Geo. Aitken Forest,	850	320,000		5,000
West River Forest,	700			4,000
Arlington Forest,	225		2,100	2,300
West Rutland Forest,	350	400,000		2,300
Mansfield Forest,	3,155	8,000,000		*
Putnam Forest,	1,100	0		0
Proctor-Piper Forest,	400	280,000		3,000
	9,555			

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†25,000 of these were planted in the fall of 1914 after the publication of the previous report.

*No estimates have been made.

**Besides this forest Mr. Hapgood deeded to the State the control of about 800 acres additional.

EXPENDITURES FOR THE YEAR ENDING JULY 1, 1915, UNDER No. 28, ACTS 1912.

UNDERHILL FOREST,		
Purchase,	$9,500.00	
Survey and estimate,	401.54	
Planting,	154.16	
		$10,055.70
CAMEL'S HUMP FOREST,		
Planting,	$ 720.31	
		720.31
DOWNER FOREST,		
Planting,	$ 392.66	
		392.66
L. R. JONES FOREST,		
Planting,	$ 364.18	
		364.18
PUTNAM FOREST,		
Purchase,	$ 174.14	
		174.14
GEO. AITKEN FOREST,		
Planting,	$ 99.73	
		99.73
TOWNSHEND FOREST,		
Planting,	$ 94.93	
		94.93
PROCTOR-PIPER FOREST,		
Survey,	$ 5.75	
Planting,	78.71	
		84.46
WEST RUTLAND FOREST,		
Planting,	$ 83.54	
		83.54
LYNDON FOREST,		
Planting,	$ 74.74	
		74.74
		$12,144.39*

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*A portion of this appropriation was unexpended in the previous year and was therefore, available for the current year.

WHITE PINE BLISTER RUST DISEASE.

Peridermium strobi.

As explained in previous reports, this serious disease of the white pine has been present in the State for several years. It was first found in the spring of 1909 on some nursery stock imported that year from Germany, but later the two worst infestations in the State were found on plantations which had been made previous to the establishment of the Forestry Department. These are on the estates of Hon. T. N. Vail in Lyndon, and the Billings Family in Woodstock.

The former infestation was due to some ornamental pines planted near Mr. Vail's house several years ago. From these the disease had spread before its discovery to a large, handsome white pine, particularly prized for its beauty, and a number of pines about fifteen feet high set out as a hedge. All of the latter, which showed signs of the disease, have been destroyed and the diseased limbs of the large tree have been removed. All currents and gooseberries on the estate have also been destroyed.

The plantation on the Billings Estate was made in 1907 with stock from a Massachusetts nursery. This had evidently been previously imported from Europe, many of the trees having shown signs of the disease. Forty-two trees had fruiting bodies in 1914, and eighteen in 1915, all of which were destroyed. The owner was urged to destroy the whole plantation and replant the land with red pine.

Of the various plantations made in 1909 with stock, part of which came from Germany, twenty-five have been inspected several different years without showing any sign of the disease. Thirty-one other plantations have shown signs of the disease, at one time or another, but only in fifteen of these have fruiting bodies actually been found. Diseased trees have always been destroyed. In the inspection made in 1915 fruiting bodies were found in only five plantations, in addition to the two described above. These were as follows:

In the plantation of Our Husbands Manufacturing Company in Lyndon four diseased trees were found. In previous years forty trees had been destroyed. Compared to 5,000, the total number planted, a very small percentage has been affected.

In a plantation belonging to Mr. Davidson in Craftsbury, one diseased tree was found, as was also the case in 1911. 2,000 trees were originally planted here.

THE WHITE OR PAPER BIRCH IS ONE OF THE MOST BEAUTIFUL TREES IN NEW ENGLAND AND IS IN MUCH DEMAND FOR TURNING PURPOSES.

In a plantation of 14,000 trees belonging to A. L. Powers in Woodstock, four were diseased. In previous years seventy-five trees had been destroyed.

On the state forest at Plainfield, where 25,000 trees were planted, three diseased trees were found.

In a plantation of 9,900 trees made by Mr. D. J. Camp in Randolph two diseased trees were found and destroyed.

From the fact that less of the disease was discovered than in previous years, it appears that the disease is being eradicated. Unless it is lying dormant in many of these trees it would seem that only a small percentage of the trees imported in 1909 were diseased and that most of these have either died or been destroyed. Careful inspection should completely eradicate this disease in time.

REPORT ON FOREST FIRES IN 1914.

BY R. M. ROSS, ASSISTANT.

As it has been the custom, during the past two years, to have the forest fire report cover the calendar year rather than the fiscal year, this report is for the calendar year 1914.

The fire hazard during that year was not nearly as great in Vermont as in some of the neighboring states. Nevertheless it was necessary for the town fire wardens to be alert and ready to respond to the several forest fire calls. During the year there were 137 fires which burned over an area of 4,058 acres. The cost of extinguishing these fires amounted to $3,368.25. Of this sum the state was required to assist the towns to the amount of $1,507.63.

As the number of fires generally have a direct relation to the precipitation, it is of interest to consider the amount of rainfall during each month of the fire season. The following table was made up from the United States Weather Bureau reports, giving the average inches of precipitation in Vermont during each month of the fire season since the year 1909.

INCHES OF RAINFALL BY MONTHS SINCE 1909.

Year	April	May	June	July	August	Sept.	Oct.	Nov.
1909..	3.0	4.6	3.1	2.6	3.1	4.2	1.5	2.0
1910..	2.4	3.8	2.9	2.4	3.7	4.5	2.0	2.5
1911..	1.1	1.3	3.9	3.5	3.9	3.8	4.1	2.2
1912..	2.7	6.4	1.8	2.7	3.9	5.3	4.1	3.3
1913..	1.9	3.3	1.7	3.7	1.5	2.2	4.9	2.0
1914..	5.0	.9	2.9	4.1	4.5	2.1	1.4	2.3

It will be noticed that during the month of May, 1914, there was only nine-tenths (.9) of one inch of precipitation, which is far less than the amount of the same month in past years. It is also very interesting to note that about 33 per cent. of the total number of fires for the year occurred in this month. Likewise the month of October had less rainfall in 1914 than during any of the past five years. Here again we note that about 16 per cent. of the total number of fires occurred in this month. While there are many other factors which enter into this subject, it will be clearly seen that precipitation plays an important part in regard to the number of fires in any year.

As in former years, a few large fires occurred and burned over a greater acreage than all the other fires together. That is, four fires burned over 2,300 acres, leaving one hundred and thirty-three fires to burn over 1,758 acres, or an average of about thirteen acres to each of these smaller fires. The largest fire of the season occurred in the town of Mount Tabor on the property of the Emporium Lumber Company. This burned over approximately 900 acres, and the total cost of fighting it amounted to $1,462.23. As the town of Mount Tabor has a very small grand list, the state was obliged to pay $1,343.36. The tract burned over had been lumbered for the past ten years, most of the valuable timber having been cut. Owing to the large amount of slash, caused by the destructive lumbering, the fire gained headway very rapidly, and it was not until after three days that it was under control. The very intense heat destroyed the forest soil and killed all young growth, so that the slope will be unproductive for several generations. Not only will this steep slope be unproductive, but erosion will follow, washing what little soil there is left down into the streams. If we are to prevent similar fires in the future, some plan must be adopted for more conservative cutting on the steep mountain slopes. There is much less danger from forest fire in lumbering operations, where the cutting has been done in accordance with forestry principles. Destructive lumbering, with no view towards reproduction, is both poor policy for the owner and a menace to the state.

Throughout the fire season fire lookout stations were maintained at the following places: Gore Mountain, in Avery's Gore; Burke Mountain, in the town of Burke; Bald Mountain, in Townshend; and Stratton Mountain, in the town of Stratton. During the fall dry season a lookout-man was stationed at Camel's Hump. During the course of the fire season these stations reported fifty-two fires to the various town wardens. In some instances, if the fires had not been discovered at the start and promptly attended to, much loss would have undoubtedly resulted. It is hoped that these lookouts will be even more efficient in the future, as the town fire wardens, each year, are cooperating much better with the lookout-men.

Besides the lookouts, patrolmen were stationed in various parts of the state where the fire hazard was particularly great. Two men patrolled the Long Trail of the Green Mountain Club, from Killington to Mount Horrid, and some of the time a third man patrolled from this point north to Bread Loaf Mountain. Besides the men who patrolled the Long Trail, there was one in the southern part of the state, in the region not overlooked by either the Stratton or Townshend Lookouts. Throughout the fire season a man was employed to patrol the Grand Trunk Railroad from Summit to Lake. This patrolman was paid through the cooperation of the Grand Trunk Railroad, Fitzgerald Land and Lumber Company, and the Forestry Department. During the year about 1,200 people were warned in regard to fires by the several patrolmen and lookout-men.

The operation of the fire lookout stations and the hiring of patrolmen, is made possible through the cooperation of the United States Government, under the Weeks Law. For the calendar year 1914 the state received $2,193.70 from the Federal Government, all of which was expended in ememploying lookout-men and patrolmen.

In order to prevent fires, it is necessary to know where the chief fire hazards are, the various causes of the fires, and the months during which there is the greatest danger of fire. Following are figures for the fire season of 1914, giving the number of fires and acres burned over during each month.

Month	No. of Fires	Acres burned
April	14	155
May	45	2,311
June	25	1,054
July	3	9
August	8	27
September	5	18
October	22	430
November	13	36
December	2	18
	137	4,058

From the above it will be noticed that there were more fires in May and also that a larger area was burned over than during any other month. This fact is also true for the fire season of 1913.

The different causes of the fires were as numerous as in past years. Each year the number of "unknown" fires is becoming less, as the town wardens are paying more attention to this matter. Below is a table giving the cause, number of fires, number of acres burned over, and also the per cent. of the total for each cause, of the number of fires and acreage burned over.

			Percent.	
Cause	Number of fires	Number of acres	Number of fires	Number of acres
Railroad	30	596	22	15
Unknown	23	1192	17	29
Brush burning	23	388	17	10
Fishermen and hunters	17	252	12	6
Smokers	13	171	10	4
Miscellaneous	13	354	10	9
Lightning	6	901	4	22
Berry-pickers	6	118	4	3
Incendiary	6	86	4	2
Total	137	4058	100	100

In the above table, "miscellaneous causes" include fires set by bee hunters, from automobiles, fire caught from burning buildings, etc.

The following table gives the number of acres burned over and cost of fighting the fires by counties.

County	Acres burned	Cost of fighting
Addison	757	$ 82.12
Bennington	182	90.91
Caledonia	56	26.00
Chittenden	647	425.75
Essex	421	373.20
Franklin	8	10.20
Grand Isle	...	....
Lamoille	9	129.53
Orange	16	27.17
Orleans	1	12.48
Rutland	1268	1,520.76
Windham	612	468.31
Windsor	55	103.08
Washington	26	98.74
	4,058	$3,368.25

In order to give a more accurate idea of the size of the various fires, the following table has been made:

	No. fires	Acres	Expense	Percent.
¼ acre or less	14	2	$ 28.97	10
From ¼ acre to 10	90	332	699.62	66
" 10 acres to 25	14	274	152.94	10
" 25 " " 100	12	600	423.92	9
" 100 " " 500	5	1250	569.57	4
" 500 " or more	2	1600	1,493.23	1
Total	137	4058	$3,368.25	100

SUMMARY OF FIRES FOR 1914

Town	Date	Duration	Cause	Area burned Acres	Damage	Expense	Warden
Arlington	April 19	7 hrs.	Berry pickers	100			Patrolman
Arlington	May 3	3 hrs.	Berry pickers	10		$ 6.96	Patrolman
Averill	May 19	2 dys.	Unknown	30		8.00	J. C. Holmes
Barre	Oct. 10	4 dys.	Incendiary	6	$ 50.00	6.00	D. T. Gregory
Barre	Oct. 12	2 dys.	Hunters	4	100.00	5.00	D. T. Gregory
Barre	Oct. 14	1 wk.	Brush Burning	6	40.00	3.00	D. T. Gregory
Barre	Oct. 12	3 dys.	Hunters	5	50.00	5.00	D. T. Gregory
Benson	Nov. 7	2 dys.	Hunters	3		4.50	D. L. Barber
Benson	Nov. 21	3 dys.	Squirrel hunters	3	None	4.50	D. Barber
Bolton	June 20	9 hrs.	Unknown	2		6.25	A. G. Stevens
Braintree	Oct. 25	9 hrs.	Unknown	2		11.00	Wm. Ladue
Brattleboro.	April 13	10 hrs.	C.V.R.R. (WRBr)	10	100.00	2.50	F. R. Thomas
Brattleboro	April 14	½ hrs.	C. V. R. R	2	15.00	2.00	F. R. Thomas
Brattleboro	April 18	4 hrs.	B. & M. R. R	3	30.00	1.00	F. R. Thomas
Brattleboro	May 31	2 dys	Smokers	75	500.00	105.66	J. G. Stafford
Brattleboro	Apr. 18	1 hr.	B. & M. R. R.	1	20.00	1.00	F. R. Thomas
Brattleboro	May 20	4 dys	Unknown	200	300.00	65.35	J. G. Stafford
Brattleboro	May 30	1 hr.	C. V. R. R.	.5	5.00	2.25	F. R. Thomas
Brattleboro	April 24	1 hr.	C. V. R. R.	¼		1.00	F. R. Thomas
Brattleboro	Nov. 6	2 hrs.	C.V.R.R. (WRBr)	1	10.00	4.00	F. R. Thomas
Brattleboro	Nov. 5	1 hr.	B. & M. R. R	½	20.00	3.00	F. R. Thomas
Bristol	May 19	4 hrs.	Brush burning	1	15.00	4.49	J. L. Guinan
Bristol	May 21	2 dys.	Brush burning	30		9.60	J. L. Guinan
Bristol	June 19	4 hrs.	Smokers	7	100.00	6.04	J. L. Guinan
Bristol	Aug. 4	5 hrs.	Fishermen	8	5.00	7.74	J. L. Guinan
Calais	July 26	3 dys.	Burning building	1	225.00	20.50	E. L. Wheeler
Castleton	Aug. 1	8 hrs.	Smokers	4		4.00	A. O. Ransom
Cavendish	May 19	10 hrs.	Unknown	30	15.00	28.00	D. J. Stimes

1600.

Charlotte	June 11	6 dys.	Smokers	30	$ 20.00	$ 13.50	H. H. Kings
Chelsea.	May 10	3 hrs.	Brush burning	8		5.22	A. J. Little
Concord	May 16	5 dys.	Brush burning	15	100.00	21.75	W. E. O'Brian
Dummerston	Nov. 13	10 hrs.	Unknown	1		2.50	E. H. Brown
Dummerston	June 26	8 hrs.	Cleaning land	½		8.00	E. H. Brown
Duxbury	May 8	1½	Brush burning	1½			P. Shonio
Elmore	July 26	7 dys.	Berry pickers	5	15.00	118.75	C. Howison
Enosburg	June 17	5 hrs.	Lightning	¼			C. H. Carpenter
Essex	April 13	2 hrs.	C. V. R. R.	5		2.80	D. Demag
Essex	May 3	6	C. V. R. R.	20		4.20	D. Demag
Essex	May 8		Unknown	20		18.00	D. Demag
Essex	May 9	5 hrs.	Smokers	10		7.70	D. Demag
Essex	May 11	4 hrs.	C.V.R.R.(Lam.Br	5		6.40	D. Demag
Essex	May 22	5 hrs.	C.V.R.R.(B.&L.)	4		13.09	D. Demag
Essex	May 18	5 hrs.	C.V.R.R.(B.&L.)	4		3.00	D. Demag
Essex	May 16	4 hrs.	Caught from hous	20		25.80	D. Demag
Essex	May 18	4 hrs.	C.V.R.R. (B.&L.)	5		26.85	D. Demag
Essex	May 28	8 hrs.	C.V.R.R. (B.&L.)	4		7.60	D. Demag
Essex	May 17	7 dys.	C.V.R.R. (B.&L.)	400		141.48	D. Demag
Essex	June 14	2 dys.	Incendiary	45		8.60	D. Demag
Essex	June 19	8 hrs.	From previous fire	10		10.00	D. Demag
Essex	June 21	8 hrs.	Incendiary	20		10.00	D. Demag
Essex	June 27	3 hrs.	C. V. R. R.	3			F. Demag
Essex	Aug. 6	5 hrs.	Clearing land	2		14.60	F. Demag
Fair Haven	Oct. 20	24 hrs.	Unknown	100		8.00	E. J. Bigelow
Fairlee	May 31	12 hrs.	Boys	1	5.00	3.20	P. Chamberlin
Glastenbury	June 14	12 hrs.	Unknown	1		3.15	J. L. Mattison
Grafton	Sept. 22	24 hrs.	Unknown	1		6.00	V. A. Wilbur
Granby	May 28	28 hrs.	Sawdust pile	300	150.00	236.45	A. W. Shores
Groton	June 2	4 hrs.	W. R. Mont.R.R.				H. M. Ricker
Halifax	May 23	30 hrs.	Smoker	10	6.00	35.00	B. G. Warden
Hardwick	May 19	10 hrs.	Incendiary	8		12.00	C. A. Stanford
Hubbardton	May 26	2 dys.	Brush burning	2		2.75	N. W. Chandler
Hubbardton	Oct. 13	2 dys.	Bee Hunters	4		1.87	N. W. Chandler
Hubbardton	Nov. 4	1 dy.	Brush burning	3		2.00	N. W. Chandler

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SUMMARY OF FIRES FOR 1914

Town	Date	Duration	Cause	Area burned Acres	Damage	Expense	Warden
Huntington	April 24	6 hrs.	Smokers	7	$ 6.00	$ .88	O. H. Morrill
Jamaica	Sept. 14	24 hrs.	C. V. R. R.	15	25.00		C. L. Sargent
Jamaica	Sept. 24	18 dys.	Lightning	½	5.00	2.64	A. H. Coleman
Jamaica	Oct. 26	24 hrs.	C. V. R. R.	20	100.00	15.64	C. L. Sargeant
Jamaica	Oct. 31	4 dys	C. V. R. R.	50	250.00	36.88	C. L. Sargeant
Jamaica	Nov. 4	24 hrs.	C. V. R. R.	2		12.41	C. L. Sargeant
Jamaica	Nov. 3	1 hr.	C.V.R.R. (WRBr)	10	5.00	3.52	L. E. Grout
Lowell	June 10	1 dy.	Fr. burn. bldg.	⅛		10.73	H. L. Pudvah
Ludlow	July 3	9 hrs.	Choppers	1		7.50	J. Wilouth
Lunenburg	Aug. 27	12 hrs.	Unknown	10	50.00		W. Balch
Manchester	June 1		Lightning	¼		1.87	F. M. Walker
Middlebury	Oct. 29	8 hrs.	Hunters	3		8.50	J. J. Champlin
Milton	May 28	1 wk.	Unknown	30	90.00	105.00	A. McNally
Monkton	Oct. 25	2 dys.	Hunters	⅛		2.75	D. W. Eddy.
Moretown	May 27	8 dys.	Unknown	2	50.00	36.24	M. C. Conway
Mount Tabor	June		Lightning	900		1,462.23	Wm. Allen
Newfane	Oct. 26	1 hr.	Smokers	⅛		.87	J. F. Whitaker
Newfane	May 9	8 hrs.	C.V.R.R. (WRBr)	20	50.00	5.96	J. F. Whitaker
New Haven	Aug. 13	6 dys.	Unknown	1½	25.00	12.00	H. C. Peck
Norton	May 18	1½ dys.	Smokers	25	100.00	39.50	R. Robichand
Norton	May 19	2 dys.	Brush burning	40	400.00	67.50	R. Robichand
Orange	Aug. 6	2 dys.	Lightning	1-10		1.75	G. E. Nelson
Plymouth	Oct. 10	10 dys.	Bee Hunters	½	25.00	3.00	H. L. Moore
Plymouth	Nov. 1	4 hrs.	Smoker	½		2.20	H. L. Moore
Poultney	June 26	6 hrs.	Berry pickers	⅛	5.00	2.00	J. F. Howe
Poultney	May 26	5 hrs.	Brush burning	⅛	2.00	3.00	J. F. Howe
Poultney	May 18	5 hrs.	Smokers	2	5.00	3.00	J. F. Howe
Poultney	May 10	3 hrs.	Smokers	¼	2.00	2.00	J. F. Howe

1,195

Poultney	Nov. 30	5 hrs.	Boys.	1-5		$ 3.00	J. F. Howe
Pownal	June 14	3 hrs.	Locomotives	5	$ 13.00		D. F. Gardner
Putney	Oct. 2	4 hrs.	Berry pickers	1	15.00	3.00	B. M. Reed
Readsboro	Oct. 11	7 dys.	Hunters	40	200.00	33.18	V. S. Thayer
Readsboro	Nov. 1	6 dys.	Incendiary	6	75.00	8.00	V S. Thayer
Ripton	May 22	2 dys.	Unknown	700	3,000.00	31.00	J. E. Hodges
Rochester	Nov. 1	12 hrs.	Unknown	1½		17.39	W. C. Henson
Rockingham	April 14	1 hr.	Automobile	2	10.00	6.50	H. A. Stoddard
Rockingham	Oct. 12		Hunters	20	80.00	7.34	H. A. Stoddard
Rockingham	Oct. 15	9 hrs.	Hunters	150	2,000.00	116.29	H. A. Stoddard
Royalton	Oct. 15	36 hrs.	Unknown	2		7.00	F. W. Howland
Rutland	April 25	2 hrs.	Hunters	2		1.00	J. H. Callahan
Rutland	April 9		Fishermen	2		1.66	J. H. Callahan
Rutland	May 17	48 hrs.	Brush burning	200		10.00	H. J. Callahan
Ryegate	Sept. 21	3 dys.	Hunters	1		5.00	T. A. Meader
Ryegate	Sept. 25		Lightning	½		3.00	T. A. Meader
Salisbury	May 11	2 hrs.	Brush burning	6			E. A. Harrington
Searsburg	May 22	4 hrs.	Brush burning	3		2.75	W. E. O'Brian
St. Johnsbury	May 21	7 dys.	Brush burning	25			Chas. Weeks.
St. Johnsbury	June 9	2 dys.	Brush burning	12		3.00	Chas. Weeks
Springfield	June 17	6 hrs.	Brush burning	4	23.25	23.25	W. D. Stearns
Stratton	June 8	3 dys.	Fishermen	1-16		10.00	D. H. Forrester
Sunderland	July 15	30 hrs.	Berry pickers	2		35.00	H. B. Lawrence.
Sunderland	Dec. 8	1 hr.	Brush burning	15			H. B. Lawrence
Sutton	May 20	2 dys.	Brush burning	5		1.00	E. L. Watson
Sutton	May 18	3 hrs.	Brush burning	2	1.00	1.00	E. L. Watson
Sutton	Dec. 8	4 hrs.	Brush burning	3		1.00	E. L. Watson
Strafford	Nov. 3	1 dy.	Unknown	5		6.00	H. D. Cummings
Swanton	May 3	24 hrs.	Unknown	8		$10.20	M. H. Donaldson
Townshend	May 19		C. V. R. R.	1		.80	C. H. Willard
Townshend	April 1		C. V. R. R.	1		4.20	C. H. Willard
Townshend	June 12	3 hrs.	C.V.R.R.(Lon.Br)	1-4			Patrolman
Townshend	June 22	1 hr.	C.V.R.R.(Lon.Br)	1			Patrolman
Townshend	Oct. 31	1 hr.	C.V.R.R.	3		3.00	C. H. Willard

5417.

SUMMARY OF FIRES FOR 1914.

Town	Date	Duration	Cause	Area burned Acres	Damage	Expense	Warden
Westminster	April 15	2 hrs.	Fr. burn. barn	10			V. Ormsbee
Westmore	Aug. 14	2 dys.	Campers	½	$ 5.00	$ 1.00	E. J. Wheeler
Westmore	Aug. 14	1 dys.	Incendiary	1		1.75	E. J. Wheeler
West Rutland	May 3	10 hrs.		25		1.75	John Nolan
West Rutland	May 1	1 dy.	Unknown	8		1.50	John Nolan
West Rutland	April 18	10 hrs.	Unknown	10		2.00	John Nolan
Windsor	Oct. 10	1½ dys.	Unknown	2		12.44	A. E. Potter
Windsor	Oct. 15	2 wks.	Hunters	10			L. E. Jennison
Windsor	Oct. 24	4 hrs.	Small boy	1½		2.30	A. E. Potter
Wolcott	June 11	7 dys.	Brush brurning	4	100.00	10.78	H. N. Cleveland
Woodbury	June 1	2 dys.	Fishermen	½	5.00	1.00	J. B. Fair
Woodbury	June 15	4 dys.	Fishermen	½		22.00	H. M. Blake

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EXPENDITURE OF STATE APPROPRIATION FOR THE YEAR ENDING JULY 1, 1915, UNDER No. 16 OF THE ACTS OF 1910.

Salaries, State Forester and Assistants,	$ 3,461.24
Charles Downer State Forest,	2,104.09
Fire Prevention,	894.34
Railroad, livery, hotels, etc., Forester and Assistants,	783.17
Clerical force,	668.00
Camel's Hump State Forest,	613.12
Postage, stationery, telephone and telegraph,	556.62
Pine disease eradication,	437.27
State Nursery at Burlington,	367.61
Instruments, tools and office supplies,	258.82
Mansfield State Forest,	247.13
Geo. Aitken State Forest,	195.73
Printing,	81.81
Lyndon State Forest,	76.25
Freight and Express,	63.85
Investigations	47.08
Insurance,	42.93
Proctor-Piper Forest,	17.60
	$10,916.66

REPORT OF RECEIPTS AND EXPENDITURES OF MONEY RETURNED TO THE STATE TREASURER UNDER No. 16 OF THE ACTS OF 1910.

Receipts.

For trees sold from State Nursery,	$2,779.78
" trees and farm produce sold from Downer Forest,	1,101.35
" trees sold from West River Forest,	295.34
" refund on exhibit burned,	175.00
" wood sold from L. R. Jones Forest,	160.29
" wood sold from Geo. Aitken Forest,	47.51
" refund on travelling expenses,	16.80
	$4,576.07

Expenditures.

State Nursery,	$2,779.78
Chas. Downer State Forest,	1,308.91
Instruments, tools and exhibits,	175.00

L. R. Jones State Forest,	148.89
West River State Forest,	99.18
Geo. Aitken State Forest,	47.51
Travelling expenses,	16.80
	$4,576.07

REPORT OF EXAMINATION MADE BY B. A. CHANDLER, ASSISTANT, ON LAND WILLED TO THE UNITED STATES GOVERNMENT BY THE LATE COL. BATTELL OF MIDDLEBURY.

Location of Land.

The land in question is located in the towns of Lincoln and Warren. The particular lots are designated on the accompanying sketch map* of these two towns. The lots as located in Lincoln were very carefully gone over by the town clerk of Lincoln, who was very familiar with all this property, and the designation of these lots can be depended upon. The town clerk of Warren was ill, and his assistant spent very little time in looking up the lands which were owned by the Joseph Battell Estate, so that I do not feel that the records of these lands is very reliable. There may be some lots designated as Battell lots which belong to other parties, and there may be other lots which are not here listed that belong with this property. However, the main location of the land and the bulk of the lots is reliable.

Topographically the land is located on the main range of the Green Mountains, the height of land being very near the town line between Lincoln and Warren. Lincoln Mountain, which is also in the property, is one of the higher peaks in the state, being 4,078 feet.

The property is not located well in relation to railroads. On the west the nearest railroad is some eight (8) miles from the land, and is only a short independent road running from New Haven Junction to Bristol. On the east the nearest railroad is the Central Vermont and is about ten (10) miles away.

Description of the Different Areas.

On the Lincoln side of the main range the tract is of comparatively little value. The upper third of the area is covered with a very thick growth of short small size spruce with a slight mixture of hardwoods. This area has not been lumbered to any great extent, and in fact is so poor and inaccessible that it will probably be a protection forest rather than a commercial lumber forest for some years to come until the market is greatly improved. The lower two-thirds is made up largely of what was originally a mixed hardwood and spruce stand out of which the spruce has been cut. Over most of the area this has left a fair stand of old growth hardwoods and in some places considerable spruce reproduction is coming in, and over more or less of the area there is a fair stand of second growth hardwood among the old growth trees. There are a few small areas where the original stand of spruce was almost pure and was cut clean which has come up to a stand of inferior hardwoods under which the spruce is seeding in. Probably the upper ridge type of spruce will not average to cut over 2,000 feet per acre, and all species of the lower type not over 5,000 to 8,000 feet of which two-thirds will be hardwood.

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*Map is omitted from this report.

The topography on this side is a decided west slope, very steep at the top but gradually becoming less steep on the lower lands. About one-third of the distance from the south end a spur from Potato Hill extends westward resulting in third quality soil extending pretty well down to the edge of the tract. There are many streams flowing in a generally westerly direction running off the tract.

There are numerous old logging roads, some of which are in fair shape and might be used for modern logging operations. Besides these there is an old road to the top of Potato Hill which has been opened up by the Green Mountain Club of the state and is used as part of its trail system. There is also an old road that was made by the Geological Survey which extends onto Potato Hill.

On the Warren side the property is extremely valuable. The third quality soil does not apparently come down the slope quite as far and the lower slopes have never been logged as heavily, and in recent years have hardly been touched. There are some areas pretty well up the mountain which will cut 50,000 feet of spruce, but of course there are others at about the same elevation which would cut only 5,000 feet of spruce per acre. Below this type of first and second quality pure spruce is the usual type of mixed hardwoods and spruce which contains some of the best spruce in the region. In fact in this valley this tract of spruce is becoming very valuable because of the fact that most of the other large holdings have been pretty well cut while this one has been reserved in very nearly its primitive condition.

The topography in this valley is more complicated than on the Lincoln water-shed. The slope is in a generally easterly direction, but there are two ridges which extend out from the main range through this property which means that that part lying north of the northerly ridge should find its market in Fayston and that the lumber in the middle basin would have to be hauled up hill to reach the village of Warren, where the only mill of the region is now located. It will probably require a special mill to utilize the material of this basin to the best advantage. Lumber from the southerly basin naturally goes into the village of Warren.

The roads through this section are few and far between except on the lower edge. However, it is a good country in which to build modern roads. I believe the timber is located in such a way that it could be cut so as to get natural reproduction and still make very profitable lumber operations.

Markets.

On the Lincoln side of the tract there are several mills all of which manufacture a little general lumber, but mostly butter-tubs and butter-boxes. This seems to be the industry of this particular region. The tract lies in such a way that a team can make about two trips a day from the skidway to the mill at Lincoln Center. From here it is about one trip a day's haul to the nearest railroad station which is Bristol. At Bristol there are several wood-using industries which are encouraging the hauling in of logs from long distances, since the supply immediately around Bristol is becoming scarce. They are doing this by offering a bonus for logs beyond certain distances. The topography and logging conditions are such in this region that it costs in the neighborhood of from $3 to $4 per thousand to cut and skid spruce. The hardwoods have been cut in this region very little, but it would probably cost from $5 to $6 a thousand to cut and skid these, possibly more. On the Warren side the market is not quite as good as far as the number of mills is concerned and distance to market, but the spruce is getting scarce on this side of the mountain. As mentioned above, it would be necessary to put in a mill to utilize to advantage part of the material. Timber which is available for the present mill, which is at Warren is about one to one and a half trips per day from the mill, although part of it would require a great deal longer haul. The teams from this Warren mill average about three trips a week from the mill to the station.

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Recreation Features.

As a recreation ground the area has some advantages over many sections of the Green Mountains. The so-called Long Trail, which has been constructed by the Green Mountain Club, extends the whole length of the tract on the main range and is travelled considerably by mountain climbers. The view from the top of Potato Hill and Ellen Mountain, which are the two peaks that make up what is known as Lincoln Mountain, is rather exceptional, even for this region, which is noted for beautiful mountain scenery. On the side of Potato Hill about an hour's walk from the top is an old log cabin which the late Col. Battell constructed for the use of the guests at his Hotel, but it has been allowed to fall into decay in recent years. It is, however, still in good enough shape so that it could be repaired and made quite liveable. Near this log cabin is a spring of very fine water.

EIGHTH

ANNUAL REPORT

OF THE

STATE FORESTER

FORESTRY IN VERMONT

AUSTIN F. HAWES
State Forester

1916

PROPERTY OF

ST. ALBANS, VT.
ST. ALBANS MESSENGER COMPANY
1916

TO THE GENERAL ASSEMBLY OF VERMONT.

In compliance with Section 2 of Act No. 11 of the Acts of 1908, I have the honor to transmit herewith my report on Forestry in Vermont.

AUSTIN F. HAWES,
State Forester.

Burlington, Vermont, July 1, 1916.

FORESTRY EXHIBIT AT LYNDON HOME GARDEN CLUB FAIR

EDUCATIONAL WORK.

The educational work of the Forestry Department has been carried on much as during the past few years. Several new charts have been added to the exhibit which has been shown at most of the agricultural fairs.

In co-operation with the Extension Service of the University of Vermont and the State Agricultural College, many lectures have been given before farmers' meetings; and conferences held in farmers' woodlots. Several of the county agents have taken an active part in interesting the people of their counties in forestry. Especially among these may be mentioned Mr. Loveland of Orange County, Mr. Sweeton of Windham County, and Mr. Deuel of Orleans County.

The following publications have been issued since the last report:

Publication No. 18.—List of Forest Fire Wardens of Vermont—1915.

Publication No. 19.—"Red Rot of Conifers"—by F. H. Abbott—Bulletin of the Vermont Agricultural Experiment Station. This bulletin is a very complete account of one of the worst forest diseases present in Vermont.

Publication No. 20.—"Studies in Tolerance of New England Forest Trees"—by G. P. Burns. Bulletin 193 of the Vermont Agricultural Experiment Station. The importance of light and moisture to forest trees makes studies of this kind of great value to the forester.

THE PRACTICE OF FORESTRY DEPENDENT ON BETTER PRICES.

During the past few years the general interest in forestry has increased encouragingly. The actual practice has also increased, but not as much as might be hoped. In other words, only a small percentage of the woodland owners are availing themselves of what the Forestry Department offers. Forest fire danger has been greatly reduced, the danger of exorbitant taxation has been remedied, and nursery stock is supplied at cost, but the prospect of greater future profits is not sufficient to induce the average person to practice forestry. Something must be done to make forestry immediately profitable. Better prices result in better dairy products and better fruit; in other words in better methods of dairying, orcharding, etc. Why should not the same hold true of the product of the woodlot? If some means can be found to help the person, who is using judgment in the harvesting of his timber, to secure better prices than his neighbor, who is butchering his lot, there will be fewer of the latter variety. Undoubtedly, there is room for a great deal of improvement in the methods of marketing wood and lumber. For several years the writer has carried on a vigorous campaign against the selling of woodlots for a lump sum; and has urged the need of careful estimates of woodlots; and the sale of produce by measure. Many lots are still sold in the old way, usually to the disadvantage of the seller.

In 1913 the Forestry Department in co-operation with the U. S. Forest Service published a bulletin on "The Wood-Using Industries of Vermont". This has undoubtedly been of considerable assistance to forest owners in enabling them to come in contact with the buyers of forest products. It is still in great demand and is nearly out of print.

The U. S. Forest Service, in co-operation with the State Foresters of New England, now plans to make a marketing study of New England, which will place in the hands of every woodlot owner a list of those using cordwood, ties, poles, posts, logs, and other rough products.

It is hoped that this study will lead to some definite and practical result in the improvement of market conditions for those who are practicing forestry. This is the day of co-operation. Farmers have their co-operative creameries and their co-operative buying and selling organizations. The writer believes that the day is not far distant when the woodlot owners of a community will organize co-operative forest products associations. The better prices which they will obtain will more than compensate them for the extra expense of removing scattered trees, etc. It will furthermore be necessary to restrict the benefits of such an organization to those who will cut only what should be cut. Otherwise there would be a grand scramble for the better prices and the forests of the community would soon be cut clean. There will naturally be several steps in the development of an efficient association of this kind. It is the writer's hope that a beginning in this direction may be made in some Vermont community at no distant date.

FOREST PLANTING.

The spring of 1916 was exceptionally favorable for forest planting, as there was a great deal of rain through May and June. Probably a larger percentage of the trees planted have lived than in most previous seasons.

Among the large planters were several municipal water boards, among them Rutland, Northfield, Bellows Falls, Chester and Springfield. More interest was manifested in Essex County than in former years.

The work of the Lyndon Home Garden Club, in this connection, deserves special notice. This Club, which is interesting the boys and girls of the region in various industrial lines, distributed the trees purchased in small quantities among its members.

It is a very encouraging sign of progress that large industrial establishments should spend money and time in forest planting. The Vermont Marble Company has been a leader in this kind of work since it was first started by Governor Proctor. A large amount of lumber is used in the boxing of marble and in other ways connected with the industry, and the company is taking steps toward perpetuating this supply on its lands in Windham and Grafton.

The three Vermont Colleges are all actively engaged in reforestation work, as shown in the list below.

The Scotch pine sold this season was all of the Riga variety. The seed from which this stock was raised was furnished the State by the U. S. Forest Service for experimental purposes. Several varieties of Scotch pine are recognized in Europe, and by comparing the trees planted this year with those set in previous years it may be possible to determine the relative value of the Riga variety for our purposes.

Altogether about five million trees have been planted in Vermont during the first eight years after the establishment of the Forestry Department. The older plantations are already attracting much attention and are of real educational value. The five thousand acres, or thereabouts, which have been planted, will form a valuable asset to the state when the timber is mature. Considering the yield of a fifty year old plantation as 35,000 feet, the total area planted may be expected to yield by 1965 over 150,000,000 board feet. At $10.00 per thousand feet this means a stumpage value of over $1,500,000. To the industries of the state, and the people employed in them, these plantations have a much greater employment value.

LIST OF TREES SOLD BY THE STATE NURSERY, 1916.

ADDISON COUNTY

Cornwall	J. E. Sperry	1,000	3 year white pine
Ferrisburg	H. S. Field	1,000	3 year red pine
Lincoln	E. S. Stevens	3,000	3 year white pine
Middlebury	F. D. Manchester	200	3 year Scotch pine
		200	3 year Norway Spruce
	Middlebury College	10	lbs. white pine seed
		2,000	3 year white pine
	Joseph A. Peck	500	3 year Scotch pine
		7,900	

BENNINGTON COUNTY

Bennington	W. S. Carpenter	250	4 year white pine
		250	3 year Norway Spruce
	The Orchards	3,000	4 year white pine
		2,000	3 year white pine
		2,000	2 year white pine
		2,000	3 year Scotch pine
		2,000	2 year Scotch pine
		1,000	3 year red pine
		1,000	3 year Norway Spruce
		1,000	3 year cedar
	C. H. Winslow	1,200	4 year white pine
Manchester	J. W. Fowler	1,000	3 year Norway Spruce
Woodford	Arthur J. Dewey	2,000	3 year Norway Spruce
		18,700	

CALEDONIA COUNTY

Barnet	Wilbur Nelson	5,000	3 year white pine
Burke	A. F. Stoddard	1,500	3 year white pine
Danville	J. B. Stanton	1,000	3 year white pine
Groton	Peter M. Abbott	1,000	3 year white pine
Hardwick	Geo. W. Bridgman	1,000	3 year white pine
	G. J. Perkins	1,000	3 year white pine
Lyndon	Wm. H. Greene	2,000	2 year Scotch pine
	Lyndon Home Garden Club	500	3 year white pine
		300	3 year Scotch pine
		200	3 year red pine
		300	3 year Norway Spruce
		200	2 year white ash
	G. T. Ruggles	2,000	3 year red pine
	A. L. Tripp	1,000	3 year Scotch pine
	D. L. Webster	2,000	3 year Scotch pine
	G. A. Whipple	2,000	2 year white pine
		2,000	2 year Scotch pine
Ryegate	Geo. F. Sanderson	3,000	3 year white pine
	F. J. Tewksbury	500	3 year white pine
St. Johnsbury	Geo. W. Caldbeck	19,000	3 year white pine
		1,000	3 year Scotch pine
	M. J. Hovey	2,000	2 year Scotch pine
Walden	F. H. & H. L. Rogers	1,000	2 year white pine
		49,500	

CHITTENDEN COUNTY

Burlington	Burlington Rendering Co.	1,000	3 year white pine
	J. E. Tracy	500	3 year cedar
	C. L. Woodbury	2,000	4 year white pine
Shelburne	J. Watson Webb	1,000	4 year white pine
So. Burlington	University of Vermont	10,000	3 year white pine
		10,000	3 year Scotch pine
Underhill	Lyman Allen	2,000	3 year white pine
		1,000	3 year Scotch pine
		28,000	

ESSEX COUNTY

Brighton	Howard H. Hobson	1,000	3 year white pine
		1,000	3 year Norway Spruce
	Sarah M. Hobson	3,000	3 year Scotch pine
Concord	Harry A. Ranney	10,000	3 year white pine
	“	2,000	3 year Norway Spruce
		1,000	2 year white ash
		1,000	3 year cedar
Lunenburg	W. E. Balch	1,000	3 year Scotch pine
		20,000	

FRANKLIN COUNTY

Enosburg	L. L. Marsh	2,000	3 year white pine
		5,000	3 year Norway Spruce
	Dr. Wm. S. Stevens	20,000	4 year white pine
		30,000	3 year white pine
		57,000	

LAMOILLE COUNTY

Hyde Park	Jesse J. Gilmore	1,000	3 year white pine
Johnson	M. E. Brewster	1,000	3 year white pine
Stowe	Harold M. Brush	3,000	3 year white pine
		2,000	3 year red pine
		1,000	3 year Norway Spruce
		8,000	

ORANGE COUNTY

Braintree	Geo. W. Flagg	2,000	3 year white pine
Chelsea	C. A. Densmore	1,000	2 year white pine
	R. H. Stanton	1,000	3 year white pine
Corinth	C. L. Speare	3,000	4 year white pine
Fairlee	Guy M. Robinson	500	3 year Norway Spruce
Randolph	Dix J. Camp	5,000	3 year red pine
	A. A. Priest	2,000	4 year white pine
		2,000	3 year red pine
		5,000	3 year white pine
Strafford	Gardner N. Cobb	2,000	4 year white pine
	John N. Titus	1,000	4 year white pine
Thetford	Mrs. Ruamie F. Colton	250	3 year white pine
	C. C. Cook	500	3 year Scotch pine
	Miss Christine Vaughan	1,000	3 year white pine
Tunbridge	G. S. Swan	1,000	3 year white pine
	J. S. Tower	1,500	3 year white pine
	Joseph Tuttle	1,500	3 year white pine
Vershire	Mrs. W. H. Orr	3,000	3 year white pine
West Fairlee	B. M. Ball	1,000	3 year Scotch pine
	H. M. Miller	1,500	3 year white pine
Williamstown	Chas. H. Beckett	10,000	3 year white pine
		2,000	3 year Norway Spruce
	Miss Martha E. Wales	1,000	3 year white pine
		48,750	

ORLEANS COUNTY

Barton	J. H. Bartlett	250	3 year white pine
Glover	M. W. Johnson	1,400	3 year white pine
	N. T. Lyman	1,000	3 year white pine
Newport	C. L. Rogers	1,000	3 year Norway Spruce
		3,650	

RUTLAND COUNTY

Clarendon	John F. Eddy	1,000	3 year Norway Spruce
	G. A. Nelson	3,000	3 year white pine
Danby	J. D. Nichols	1,000	3 year white pine
Proctor	Miss Emily D. Proctor	25,000	4 year white pine
Rutland	City of Rutland	50,000	4 year white pine
		30,000	3 year white pine
	Jacob Theilman	1,000	4 year white pine
Shrewsbury	O. G. Knight	1,000	3 year white pine
	Theodore G. Pearson	500	3 year white pine
		500	3 year Norway Spruce
West Rutland	Chas. H. Campbell	500	4 year white pine
	Frank Partridge	25,000	4 year white pine
		138,500	

WASHINGTON COUNTY

Barre	Lewis D. Martin	2,000	3 year white pine
	D. A. Perry	2,000	2 year white pine
Berlin	T. D. Hobart	1,000	4 year white pine
		500	3 year Norway Spruce
Cabot	L. C. Fisher	6,000	3 year white pine
	Geo. Gould	1,000	3 year white pine
	Arthur Jacobs	250	3 year white pine
Calais	Ralph Putnam	10,000	3 year white pine
East Montpelier	Harry Daniels	3,000	3 year white pine
Marshfield	J. W. Mears	3,000	3 year white pine
Middlesex	Ralph Putnam	5,000	3 year white pine
Montpelier	P. L. Cleveland	2,000	3 year white pine
	O. L. Tillotson	1,000	3 year white pine
Moretown	Bertram Ward	8,000	3 year white pine
		2,000	3 year Norway Spruce
Northfield	Wm. B. Mayo	5,000	3 year white pine
	Norwich University	1,000	4 year white pine
		1,000	3 year red pine
	Chas. A. Plumley	10,000	3 year white pine
	Village of Northfield	5,000	3 year white pine
Plainfield	Herman Dix	4,000	3 year white pine
Waitsfield	Richardson Bros.	1,300	3 year white pine
Waterbury	C. A. Perry	3,000	3 year white pine
	H. P. Robinson	1,000	3 year white pine
	Vermont Hospital for Insane	10,000	4 year white pine
		88,050	

WINDHAM COUNTY

Brattleboro	Mrs. L. S. Barber	1,000	3 year white pine
	Merrett Fisher	1,000	3 year white pine
	O. L. French	1,000	3 year Scotch pine
Dummerston	John H. Evans	2,000	3 year white pine
	J. Lewis Morse	1,500	3 year white pine
		1,000	3 year Scotch pine
		1,000	3 year Norway Spruce

Grafton	Vermont Marble Co.	25,000	4 year white pine
		25,000	3 year Norway Spruce
Guilford	E. B. Barrows	5,000	3 year white pine
Marlboro	J. M. Johnston, Jr	5,000	3 year Norway Spruce
		1,000	2 year white ash
	B. H. Whitacre	2,000	3 year red pine
Rockingham	Harry Barnes	500	2 year white ash
	Bellows Falls Corporation	10,000	2 year white pine
	H. A. Davis	500	3 year white pine
	L. S. Hayes	1,000	4 year white pine
		500	3 year Scotch pine
		500	3 year red pine
	Rodney W. Roundy	1,000	3 year white pine
	John R. Walsh	500	3 year white pine
Westminster	Robert G. Harlow	1,000	2 year white pine
	R. H. Ranney	2,000	3 year white pine
Wilmington	Martin A. Brown	500	3 year white pine
		500	3 year Norway Spruce
		90,000	

WINDSOR COUNTY

Cavendish	Miss Fanny B. Fletcher	1,000	3 year white pine
Chester	Village Water Dep't.	5,000	3 year white pine
Hartford	A. P. Clifford	2,000	3 year white pine
	W. H. Seaver	1,000	3 year white pine
Hartland	Nathaniel Jenne	3,000	3 year white pine
	C. H. Lamb	3,000	3 year white pine
Norwich	Geo. H. Cossingham	1,000	3 year white pine
Royalton	Mrs. E. J. Fish	1,000	3 year white pine
	Homer Russell	1,000	3 year white pine
Springfield	S. W. Butterfield	4,000	4 year white pine
		1,000	3 year white pine
	Village of Springfield	5,000	3 year white pine
Woodstock	James D. Aitken	1,000	3 year white pine
	Fay J. Burnell	250	3 year white pine
	H. H. Daniels	4,000	3 year white pine
	Miss Elizabeth Hall	500	3 year white pine
		500	3 year Norway Spruce
	Richard M. Marble	500	3 year Norway Spruce
		1,000	2 year white ash
	L. L. Mounce	5,000	3 year white pine
	Everett V. Perkins	50	3 year white pine
		50	3 year Scotch pine
		50	3 year red pine
		50	2 year white ash
		50	3 year cedar
		41,000	

SUMMARY OF TREES PLANTED IN 1916, BY COUNTIES.

Addison County, Private planting	7,900
Bennington County, Private planting	18,700
Caledonia County, Private planting	49,500
" " State planting	2,000
Chittenden County, Private planting	28,000
Essex County, Private planting	20,000
Franklin County, Private planting	57,000
Lamoille County, Private planting	8,000
Orange County, Private planting	48,750
Orleans County, Private planting	3,650
Rutland County, Private planting	138,500
" " State planting	159,000
Washington County, Private planting	88,050
" " State planting	213,000
Windham County, Private planting	90,000
Windsor County, Private planting	41,000
" " State planting	154,000
	1,127,050

THE STATE FOREST NURSERIES.

The State Nursery has now been in operation for ten years. It was started through the activities of the Vermont Forestry Association at a time when there were practically no private nurseries selling stock at prices attractive for forestry purposes. It was the policy of the Forestry Department to increase the capacity gradually as the demand for stock grew. That there has been a healthy growth in this demand may be seen by perusing the annual reports of the department. At the time the Downer State Forest was given to the State the donor expressed the wish that a nursery should be maintained on the forest. A small nursery was, therefore, started with the object of meeting the local demands for nursery stock. The demand grew so rapidly for a few years that the Board of Agriculture and Forestry urged a considerable increase in the capacity of the nurseries, since it requires three years to bring seedlings to the age for planting. Of late years, however, the growth in the demand has not been as rapid, and by a recent action of the Board the size of the nurseries has been left entirely to the discretion of the State Forester. Because of the danger of the Blister Rust disease he has decided to give up the raising of white pine, for the present, in the Sharon nursery, but to raise Norway spruce, Scotch pine, etc.

Now that the nurseries can be reduced to the needed capacity, it is believed that less planting should be done on state forests. Although the plantations of the "productive state forests" will undoubtedly prove good investments in time, they have not the educational value that those on the "demonstration forests" have. They are more expensive to make because of their inaccessibility, and will not be as profitable because the soil is poorer and because of the distance from the markets. It should, therefore, be the policy of the department to spend its funds for the next few years in ways which will be of greater educational value than in making extensive plantations on mountain slopes, much as these are needed.

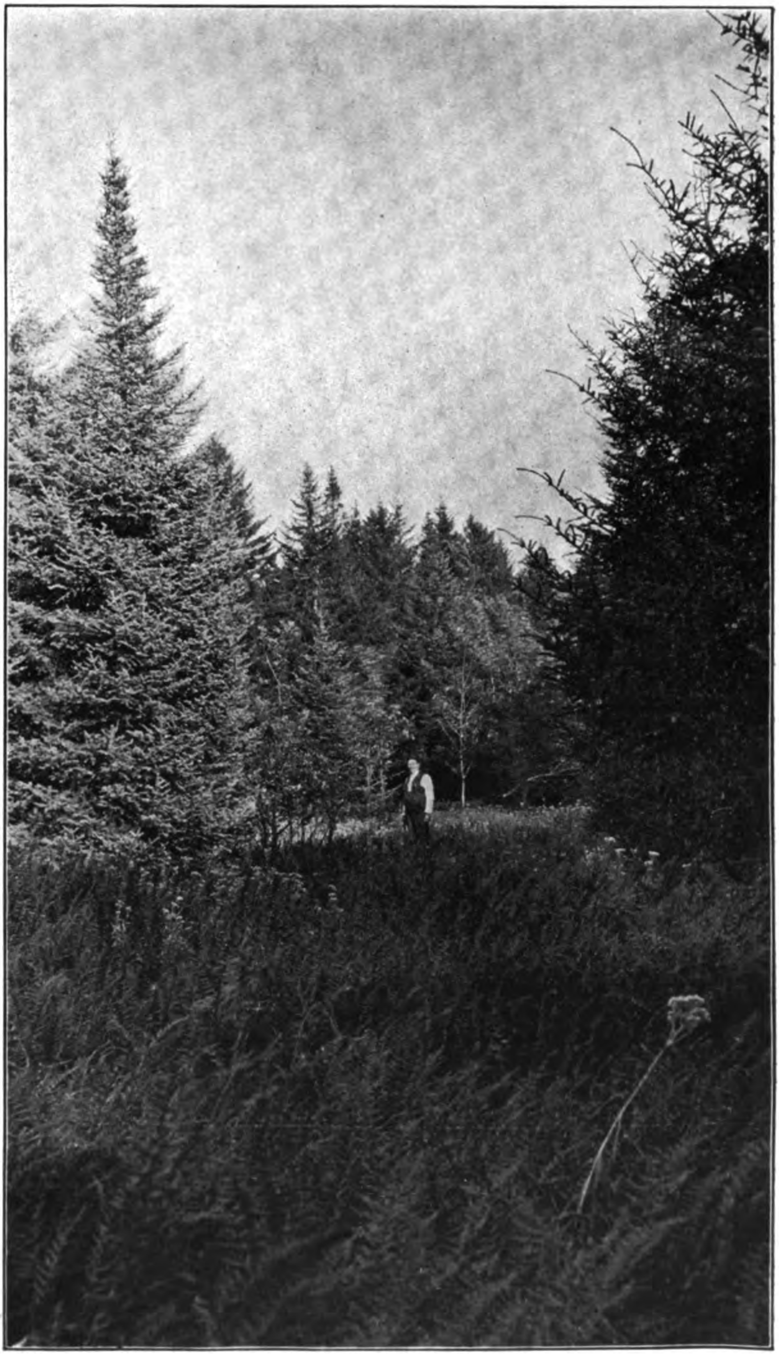
At the suggestion of the Board of Public Printing, the usual inventories of the State nurseries are omitted from this report.

VERMONT STATE FORESTS.

The Forestry Department has established two classes of state forests, based upon the purpose for which they are acquired.

(a) Demonstration forests are selected principally for their educational value and are located in accessible situations where they can be easily reached by a large number of people. So far as possible they are also selected with regard to special forest problems that need to be studied. It is not expected that these small areas will be of any material profit to the state, or that they will affect the water or timber supply. Indirectly, however, they will produce these results through their educational influence upon private owners.

(b) Productive forests are large areas selected with little regard to their educational value, but for the more direct benefit to the state. By their size they will have a beneficial influence upon the water supply, upon the local supply of high grade lumber for the maintenance of industries, and upon the scenery. In the long run they will be profitable to the state because the carrying charges and administrative expenses of these large areas will be comparatively small.



SECOND GROWTH SPRUCE ON WORN OUT PASTURE.

DEMONSTRATION FORESTS.

Nine of the state forests may be considered as in this class. They are widely distributed over the state, and are already serving a very valuable educational purpose.

CHARLES DOWNER FOREST.

This was the first forest acquired by the State, and the plantations made here in 1910 are now extremely interesting, especially those of Scotch, Norway and White Pine. During the past year the Board of Agriculture and Forestry has made a change in the administration of this forest. Beginning on January 1, 1916, Mr. Amos J. Eaton has acted as superintendent of the forest. From his home in Royalton he has been able to inspect the forest at frequent intervals, and this has resulted in a more efficient management. In order to obviate the expenditures which have hitherto been made for agricultural purposes, the farm was leased to Mr. J. E. Wilder, the former superintendent. A silo has been built and all the buildings painted. Mr. Wilder has equipped a dairy, and will run this in connection with the nursery work which he is carrying on for the State. Hereafter the nursery stock is to be raised at contract prices not to exceed the cost of raising in the Burlington nursery. There was sown in the spring of 1916:

14 lbs. Norway spruce seed,
10 lbs. Scotch pine seed,
1 ounce each of the following:
    Abies balsamea,
    Abies concolor
    Abies grandis,
    Abies biloba,
    Libocedrus decurrens,
    Picea alba,
    Picea engelmanni,
    Picea pungens,
    Pinus maritima,
    Pinus ponderosa.

The white pine plantations made in previous years were filled in, and an extensive plantation was made on the land given by Mr. Downer more recently. The trees planted consisted of 147,000 white pine, 3,000 Norway spruce, and 4,000 red spruce. The total number of trees planted to date on this forest is as follows:

Species.	No. Planted.
White Pine,	250,000
Red Pine,	22,700
Scotch Pine,	19,000
Austrian Pine,	2,400
Norway Spruce,	57,000
Colorado Blue Spruce,	100
Red Spruce,	4,000
Red Fir,	5,000
Black Locust,	3,000
European Larch,	4,000
White Ash,	15,000
	382,200

The reproduction cutting made here a few years ago is already producing good results. Seedlings of ash and basswood as well as maple are numerous. During the past winter a light cutting was made in another section of the woodlot. Only the poorest trees were cut.

L. R. JONES FOREST, PLAINFIELD.

Most of the open areas of this forest have now been planted. The few remaining places were filled in during the past spring with 10,000 Norway pine, and 10,000 Norway spruce.

This forest offers special opportunities for demonstrating proper methods of handling second growth spruce, a type which is so common on the abandoned pastures of the State. Another interesting type here is made up of white birch, which can be marketed to good advantage within a few years. The chief problem in the handling of this forest is to find a market for the large amount of cordwood which should be removed.

LYNDON SAND FOREST PLANTATION.

From an educational standpoint this forest is perhaps doing as much as any of the larger areas. Although only 75 acres in extent the splendid plantations of Scotch pine set out in 1912 are now attracting wide attention. They are plainly visible from the B. & M. R. R. In the fall of 1915 two square plots of shifting sand were surrounded with brush fences, and in the spring of 1916 these plots were planted with Scotch pine. The open board fence which was built on the crest of the sand wave is proving successful in stopping the advance of the wave. Especially encouraging is the growth made by the sand binding grasses from Cape Cod. The bunches originally planted are already spreading out and it is only a question of a few years before this grass will cover the whole wave and make possible the planting of pine.

GEORGE AITKEN FOREST, MENDON.

During the past year work has been continued in transforming the burned hardwood stands to valuable softwoods. The wood is sold on the stump to men of the neighborhood, thus furnishing considerable winter work. The price paid is 85c a cord with the condition that the purchaser burn all the tops and thus leave the land in good condition for planting to pine. In this way the income for the wood is nearly enough to pay for restocking, and for a slight outlay a promising softwood stand is substituted for deteriorating hardwoods. This forest has great educational possibilities.

WEST RIVER FOREST, TOWNSHEND.

No new work has been done on this forest. The plantations made in former years are now plainly visible from the West River R. R. and are attracting much attention. Because of its situation near a large village this forest will be more and more useful as the demonstrations mature.

ARLINGTON FOREST.

The plantations made on this forest are also doing well and there has been no need of further work during the past year. There has been some talk of establishing a wood alcohol plant in this valley, and if such a plant were ever built it would make possible a much needed thinning in the hardwood stand.

WEST RUTLAND FOREST.

In 1915 the experiment in fall planting was continued on this forest. Because of the scarcity of labor in the spring in many parts of the State, numerous letters are received by the Department asking if planting can be done at any other time. Evergreen trees cannot safely be planted during the growing season, which usually lasts from about June 1 to August 20. Neither is it considered safe to plant late in the fall, because the trees cannot become well rooted before frost. 25,000 four year white pines were planted in September 1915 on this forest to test that time. After the trees were shipped the weather turned very hot, but as the trees could not be kept they were planted. The result, as shown in the spring of 1916, was decidely discouraging for fall planting. In the case of an owner who wishes to plant only a few thousand trees it may be safe to plant in the fall, because favorable days may be selected, but the Department will not hereafter undertake any extensive planting at that season.

In the spring of 1916 the failed placed in the previous plantations were filled, and the remaining open areas planted. The trees used were as follows:

White pine, 4 years,	25,000
White pine, 3 years,	55,000
	80,000

The total number of trees planted on this forest to date is as follows:

White pine, 4 years,	60,000
White pine, 3 years,	79,000
Red pine, 3 years,	10,000
Norway spruce, 3 years,	5,000
European larch, 3 years,	5,000
	159,000

PROCTOR-PIPER FOREST TRACT.

This forest contains some very interesting types, and because of its location near the village of Proctorsville, is excellent for demonstration purposes. Besides considerable areas of second growth there are two stands of good old growth timber. This includes considerable large hemlock and maple and some exceptionally good white ash. As soon as a market can be found for block wood and the poorer grades of lumber, a reproduction cutting will be made, with a special effort to reproduce ash and basswood. The plantations made in 1915 are doing well and will soon have an educational value.

PRODUCTIVE FORESTS.

Three of the state forests may be considered in this class, with a total area of 7,500 acres. In all they protect the headwaters of several important tributaries of the Winooski River.

BATTELL FOREST, CAMEL'S HUMP, DUXBURY AND HUNTINGTON.

On the east side of the mountain several brooks come together to make one large brook emptying into the Winooski River at North Duxbury. After the extensive forest fire of 1903, which burned several thousand acres on the mountain, the mill owners noticed a pronounced diminution of the stream flow, so that their mill capacities have been seriously affected. While the brush that has followed since the fire has some influence on evaporation in summer, it has little upon the melting of the winter snows. Hence it is important to these brooks that these slopes be reforested with such trees as spruce. The brook flowing from the mountain through Honey Hollow is also protected by maintaining the forest cover.

Elsewhere in this report under the title: "Close Utilization of The Forest", the timber supply, and the industries of the North Duxbury Valley have been considered. Although this is not classed as a demonstration forest it may be of interest to note that the management of the state forest is responsible for the encouraging local sentiment for conservation. It was the state fire protective system that first interested the mill owner in a perpetual supply of timber. Previously he had feared a repetition of the fire of 1903, which nearly ruined the valley. With proper reforestation of the areas having a fair soil a considerable timber supply can be assured these mills within a reasonable period. The box mill will make thinnings possible and thus exhilarate the growth.

Because of the expense in transporting trees by ox cart up onto the high slopes, an experiment was made late in the fall of 1915 in hauling the trees (all Norway spruce) up on sleds and keeping them over winter preparatory to planting. Two methods of keeping them were tried. 12,000 trees were heeled in just as is done in ordinary planting operations. 13,000 were buried in a snow pit according to a method used in parts of Europe, especially in the higher mountains. A hole was dug three or four feet deep, and the bottom was covered with snow well tramped down. A layer of twigs and then a layer of earth was put in. A layer of transplants was then laid down and on this layers of twigs, earth,. trees, etc., continued until the hole was full. In the spring most of the trees were planted, but some were discarded because the needles had fallen off. At the time of writing it is apparent that neither of these methods is satisfactory, although the trees that were heeled in have done much better than those in the pit. Of those heeled in, the trees on the outer edges were in better condition because they had better ventilation. Many of the others were badly moulded.

Besides the trees above mentioned there were planted 75,000 Norway spruce from the Sharon nursery, and 20,000 arborvitae from Burlington. The total number of trees planted to date on this forest is as follows:

Norway spruce,	190,000
Arborvitae,	20,000
White pine,	8,000
Scotch pine,	3,000
	221,000

Of the pines planted in 1913, a large proportion have been damaged by deer eating off the tops.

Fire lines have been made to protect the plantations from fire.

From the standpoint of scenery this is one of the most important state forests, as Camel's Hump is visited annually by a large number of people. In order to make it more available considerable work has been done on the trails by the lookout watchman during the wet weather. The new trail from North Duxbury to the summit is now in good condition, and the same may be said of the trail up from Honey Hollow. The Bolton and Huntington trails have been improved so far as they are on state land.

The object of management of the state forests is to make them of use to the greatest number of people possible. Rough fire places have been constructed in places so that fires may be built without danger to the forest.

MANSFIELD FOREST, UNDERHILL AND STOWE.

In the fall of 1915 a large area in the town of Stowe was purchased, which connects with the land already owned by the State in Underhill. This addition makes this the largest state forest in Vermont with an area of about 5,000 acres; and next to the Crawford Notch Forest, the largest state forest in New England. It extends from the Cambridge to the Bolton line. The original purchase was wholly on the west side of the main Green Mountain range and somewhat south of Mount Mansfield. The new purchase covers most of the east slope of Mansfield proper, although a small corner is on the west side of the mountain. It comes as far down the mountain on the east side as to cross the Smuggler's Notch road, just south of Barne's Camp.

In connection with this it is of interest to note that a strip of land 40 rods wide on each side of the summit of Mount Mansfield, and including, therefore, the highest land in Vermont, is owned by the University of Vermont, through a deed received in 1859. As might be expected from its elevation, there is little timber on this strip. Some of the land purchased by the State in Stowe had been the subject of a law suit between the Burt Lumber Company and H. E. Shaw, owing to a controversy over a boundary line. Title was secured to certain disputed lots from both parties. The price paid was reasonable because of the desire of the contestants to settle the dispute without further litigation. In addition to the purchase the State secured a permanent lease of a town school lot for an annual rental of $5.00.

In view of the low price paid for these holdings, the owners reserved the right to remove the merchantable timber during a very limited period, but in each case the word "merchantable" was defined. The region is so far from the market that there is little danger of the slope being seriously denuded. Enough growing timber will be left to make this a valuable forest within a few years, especially if new wood using industries can be established.

From the standpoint of water supply the Mansfield Forest is very important. Three large brooks rise in the forest on the west side: Stevens and Clay brooks, and Lee River. On the east side the West Branch of the Waterbury River has its source. There are many beautiful waterfalls in the forest, and no doubt these brooks are of importance for fish culture.

Mansfield is more widely known than any of our mountains and is visited every year by hundreds of people. In connection with Smuggler's Notch, there is here the grandest scenery in the Green Mountains, and for this reason if for no other, the forest should be protected.

The Forestry Department is co-operating with the Green Mountain Club in maintaining the Long Trail, and has built some additional trails. A ranger's cabin has been constructed in the Lee River valley and a trail has been built from this to connect with the Long Trail and the summit of the mountain. Another trail from the Long Trail leading down to Stevensville was built in the fall of 1915.

PUTNAM FOREST, WORCESTER.

In the spring of 1916 the C. C. Putnam & Son Lumber Company gave an additional 200 acres to the State. This joins the tract previously given and makes the total area about 1,300 acres. It lies on the east side of the Worcester mountain range, and was nearly all burned over in 1903. This is a secondary range of the Green Mountains and is little visited by tourists. Its value to the State, therefore, is not so great for the protection of scenery, as for its influence upon stream flow, and timber production.

Reference is made elsewhere in this report to the efforts being made by land owners in the Worcester valley to preserve the timber and dependent industries. Most of the land of this state forest is suitable for raising spruce timber, although some of it is so ledgy that it would hardly pay to plant it at present. Some of the best soil was planted in the spring of 1916 with the following trees:

White pine,	10,000
Balsam,	2,500
Norway spruce,	60,500
	73,000

Because of the inacessibility of the tract the planting was done, as at Camel's Hump, with a large crew camping on the forest. The brooks rising on this tract flow into the North branch of the Winooski River and their perpetuation is of special importance to the industries of Putnamville, Wrightsville and Montpelier.

SUMMARY OF TREES PLANTED ON STATE FORESTS, 1916.

Caledonia County	Lyndon	2,000	Scotch pine	2,000
Rutland County	West Rutland	139,000	white pine	
		10,000	red pine	
		5,000	Norway Spruce	
		5,000	European larch	
				159,000
Washington County	Plainfield	10,000	red pine	
		10,000	Norway spruce	
				20,000
	Duxbury	100,000	Norway spruce	
		20,000	Arborvitae	
				120,000
	Worcester	10,000	white pine	
		2,500	balsam	
		60,500	Norway spruce	
				73,000
Windsor County	Sharon	147,000	white pine	
		3,000	Norway spruce	
		4,000	red spruce	
				154,000
				528,000

APPROXIMATE AREA OF STATE FORESTS.

Name	Area Acres
Chas. Downer,	800
L. R. Jones,	600
M. J. Hapgood,*	100
Battell,	1,200
Lyndon,	75
Geo. Aitken,	850
West River,	700
Arlington,	225
West Rutland,	350
Mansfield,	5,000
Putnam,	1,300
Proctor-Piper,	400
	11,600

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*Besides this forest, Mr. Hapgood deeded to the State the control of about 800 acres.

WHITE PINE BLISTER RUST DISEASE.

(*Cronartium Ribicola.*)

This disease of the white pine was imported into this country on nursery stock from Europe as early as 1900. It was not until 1909 that it was found in Vermont, in which year a large supply of pine was imported through the Forestry Department to fill the increased demand for stock. In the same year it was imported into New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, New Jersey, Ohio, and Indiana. During the inspections made following the discovery of the disease on the imported trees it was found on trees planted in former years on the Billings Estate in Woodstock, and at Speedwell Farms, Lyndon. Evidently these trees, purchased from a Massachusetts nursery, had originally been imported. So far as is known no diseased pines have been brought into Vermont since 1909.

The disease first manifests itself as a swelling on the stem of the seedlings. About the middle of May orange fruiting bodies break through the bark, from which spores are spread by the wind. One of the difficulties in suppressing the disease is due to the fact that trees may apparently be diseased for a number of years, possibly ten, without showing it. The turning brown of pine needles, which is commonly due to weather condition, should not be confused with this disease.

The only encouraging factor about the disease is that it cannot spread from one pine tree to another. The spores from the pine can germinate only on the leaves of either currant or gooseberry. Spores borne on the Ribes may be carried from one Ribes to another so that it can spread considerable distances in this way. Another kind of spore is formed later which attacks the pine, in this way completing a rotation.

The best way to combat the disease, therefore, is to destroy all infested pine and also all plants of Ribes within a limited distance, perhaps a quarter mile.

Since the first discovery of the disease in 1909, the Forestry Department has carefully inspected all the plantations each year and has taken every possible means to eradicate it. That its efforts have not been in vain are evidenced from statements received indicating that the present condition of the disease in Vermont is less serious than in Ontario, Massachusetts, or Connecticut. If the disease can be eradicated in the latter sections we may be optimistic about the situation in Vermont. If, on the other hand, it cannot be controlled in those states, it will eventually gain entrance into Vermont in many places and be impossible to check. So far as the present standing pine is concerned there is probably little danger of its destruction. The chief danger of this disease is the damage it does to reproduction whether natural or artificial.

In the summer of 1915 several new infestations of the disease were discovered in Massachusetts, and elsewhere, so that it became evident that national action must be taken if it was to be controlled. An Inter-State Committee was formed, on which Vermont was represented by the State Forester, and assistant. This Committee met in Boston and prepared a program which was laid before Congress with the result that an initial appropriation of $20,000 was secured for prosecuting the work.

Under this appropriation the Vermont Forestry Department in co-operation with the U. S. Department of Agriculture employed five temporary assistants for the period between May 15th and July 1, in carefully inspecting all plantations which were likely to have the disease. The result of this inspection is tabulated below:

County	Town	Name	No. of Trees		Date of Inspection 1916	Inspected by	Infection Found		No. Removed	
			Plant-ed	% alive			Pine	Ribes	Pine	Ribes
Chittenden	Essex	Jones & Howe	(1500) found 4,500	90	June 17	Putnam	0	0	0	0
Chittenden	Essex	F. Spaulding	2,000	50	June 17	Putnam	0	0	0	2
Franklin	Franklin	Chas. W. Gates	500	50	May 29	Squire	0	0	0	0
Franklin	Franklin	Chas. W. Gates	500	80	May 29	Squire	0	0	0	0
Franklin	Enosburg	Dr. Wm. S. Stevens	9,000	85	May 29, June 1 & 2 June 23-27	Squire	13	0	7,013	92
Franklin	Enosburg	Dr. Wm. S. Stevens	2,600	85	May 29	Squire	0	0	0	1
Franklin	Fletcher	Fred L. Smith	1,000	50	June 23	Squire	0	0	0	16
Rutland	Pittsfield	W. E. Ellis		27 trees	May 19	H. H. Squire	0	0	0	0
Rutland	Pittsfield	W. E. Ellis			Not Inspected					
Rutland	Mendon	Gen. Ripley Est.	500	60	June 13	H. H. Squire	0	0	0	0
Bennington	Peru	O. F. Coolidge	300	5	June 12	H. H. Squire	0	0	0	0
Bennington	Manchester	J. M. Fowler	250	50	June 12	H. H. Squire	0	0	0	0
Bennington	Manchester	C. A. Rich	1	100	June 12	H. H. Squire	0	0	0	0
Addison	Salisbury	Samual Kelly	1,000	80	June 13	H. H. Squire	0	0	0	10
Caledonia	Lyndon	T. N. Vail	about 300	100	May 24	A. J. MacNab	20	0	20	1
Caledonia	Lyndon	A. B. Pratt	5,000	95	May 26	A. J. MacNab	1	0	1	0
Caledonia	Barnet	M. D. Gibson	1,000	98	May 27	A. J. MacNab	0	0	0	0
Caledonia	Ryegate	M. H. Gibson	1,500	80	May 29	A. J. MacNab	0	0	0	32
Caledonia	Hardwick	Miss Alice Bronson	2,000	60	June 29	H. N. Putnam	0	0	2	87
Washington	Montpelier	Park Commission	3,000	90	June 17	A. J. MacNab	0	0	1	0
Washington	Berlin	D. W. Gross	100		Not Inspected					
Washington	Berlin	D. L. Ladeau	400	6	May 15	H. H. Squire	0	0	0	0

Washington	Middlesex	J. A. Chapin	500	80	May 12	H. H. Squire	0	0	0	0
Washington	Middlesex	Dr. Brock	1,000	50	May 12	H. H. Squire	0	0	0	14
Washington	Northfield	F. A. Jones	500	35 trees	May 20	H. H. Squire	0	0	0	0
Washington	Plainfield	State of Vt.	25,000	·	June 7	H. Coombs			5,000	0
Washington	Plainfield	O. L. Martin	1,000		June 8	H. Coombs	0	0	0	7
Windsor	No. Pomfret	C. P. Thatcher	1,000	60	May 18	H. H. Squire	0	0	0	0
Windsor	No. Pomfret	A. E. Sherburn	2,000	70	May 18	H. H. Squire	0	0	0	3
Windsor	So. Royalton	S. J. Vail	500	95	May 18	H. H. Squire	0	0	0	48
Windsor	Bethel	E. L. Bass	500	85	May 19	H. H. Squire	0	0	0	4
Windsor	Sharon	Chas. Downer St. For.	4,000		May 29	R. M. Ross	9	0	9	15
Windsor	Sharon	Chas. Downer St. For.			May 30	R. M. Ross	19	0	1000	4
Windsor	Sharon	Chas. Downer St. For.			May 29	R. M. Ross	0	0	0	0
Windsor	Springfield	O. W. Bishop	1,000	80	June 2	H. N. Putnam	0	0	0	14
Windsor	Springfield	W. G. Taylor sold to Horace B. Boothby	1,000	95	June 2	H. N. Putnam	0	0	0	2
Windsor	Springfield	Eugene Spellman	1,500	85	June 11	H. N. Putnam	0	0	0	9
Windsor	Springfield	J. W. Jordon	3,000	10	June 7	H. N. Putnam	0	0	0	2
Windsor	Springfield	Charles Stone	1,000	85	June 7	H. N. Putnam	0	0	0	9
Windsor	Springfield	Fred Carlos Davis	2,000	10	June 6	H. N. Putnam	0	0	0	173
Windsor	Springfield	C. W. Lawrence	2,000	95	June 3	H. N. Putnam	0	0	0	0
Windsor	Springfield	Fred Charles Davis	1,000	20	June 5	H. N. Putnam	0	0	0	30
Windsor	Springfield	W. D. Woolson	40,000	85	May 25 to June 2	H. N. Putnam	0	0	0	318
Windsor	Cavendish	S. W. Slack	500	20	June 15	H. N. Putnam	0	0	0	0
Windsor	Weathersfield	Miss Mary Woodbury	10,000	82	June 13	H. N. Putnam	0	0	0	4
Windsor	Woodstock	A. L. Powers	14,000		May 24-26	R. M. Marble	55	0	55	3 patches
Windsor	So. Woodstock	C. B. Snell	3,000		May 19	R. M. Marble	8	0	8	2
Windsor	Woodstock	Billings Estate	10,000		May 27-29	R. M. Marble	5	0	5000	0
Windsor	Woodstock	Billings Estate			May 16	R. M. Marble	3	0	3	0
Windsor	Woodstock	Billings Estate			May 31 J 2	R. M. Marble	2	0	2	0
Windsor	W. Woodstock	W. E. Mack	250		May 15	R. M. Marble	0	0	0	0
Windsor	Woodstock	Theodore Field	1,000		May 17	R. M. Marble	0	0	0	0

County	Town	Name	No. of Trees		Date of Inspection 1916	Inspected by	Infection Found		No. Removed	
			Planted	% alive			Pine	Ribes	Pine	Ribes
Windsor	So. Woodstock	M. Holt	1,000		May 22	R. M. Marble	0	0	0	0
Windham	W. Townshend	C. H. Carr	500	95	June 4	Squire	0	0	0	0
Windham	So. Londonderry	B. S. Gallup	2,000	95	June 8	MacNab	0	0	0	0
Windham	Westminster	Fred Lane	200	Destroyed	June 2	MacNab	0	0	all 1909 stock	5
Windham	Westminster	D. P. Wright	(4800) 5000	98	June 1	MacNab	2	0	2	20
Windham	Rockingham (Bellows Falls)	C. E. Howard	500	Destroyed	May 31	MacNab	0	0	all 1909 stock	0
Windham	Brattleboro	C. W. Richardson	5,000	92	June 11	MacNab	0	0	0	0
Windham	Brattleboro	H. L. Emerson	5,000	20	June 11	MacNab	0	0	0	0
Windham	Brattleboro	E. B. Barrows	2,000	98	June 10	MacNab	0	0	0	0
Windham	Brattleboro	E. L. Hildreth	2,000	90	June 10	MacNab	0	0	0	0
Windham	Dummerston	C. C. Fitts	5,000 1909 5,000	98	June 6	MacNab	0	0	0	0
Windham	Dummerston	Holden & Martin	1910 15,000	98	June 4	MacNab	0	0	0	0
Windham	Dummerston	Scott Farm	3 sec. 5,000	95	June 7	MacNab	1		1	10
Windham	W. Townshend	D. S. Brownell	2,000	90	June 5	Squire	7	0	7	3
Orleans	Craftsbury	P. W. Davison	2,000	85	June 30	Putnam	0	0	0	1
Orleans	Craftsbury (Pond Village)	H. F. Graham	3,000	80	July 1	Putnam	0	0	0	8
Orange	Brookfield	Miss Anna Clark	2,000	80	May 20	Squire	1	0	1	5
Orange	Chelsea	C. A. Densmore	2,000	90	May 16	Squire	0	0	0	14
Orange	Newbury	C. H. Bailey	5,000	95	May 30	MacNab	0	0	0	0
Orange	Williamstown	P. A. Alexander to J. J. Alexander	500	80	May 20	Squire	0	0	0	0
Orange	Washington	L. D. Tillotson	2,000	90	May 16	Squire	0	0	0	63
Lamoille	Stowe	C. E. & F. O. Burt	5,000	90	May 13	Squire	0	0	0	0

FOREST FIRE REPORT FOR 1915.

BY R. M. ROSS, ASSISTANT.

As it is much more satisfactory to consider the fire season for the calendar year rather than for the fiscal year, this report covers the calendar year of 1915.

Most of the fires this season occurred during the month of April, which was the driest since 1911. The total number of fires for the year was 137, occurring in eighty towns and burning over an area of about 4,397 acres. The cost of extinguishing amounted to $4,300.26. Of this sum the State was called upon to pay $2,449.21 for fighting the largest fire of the season, which occurred in the unorganized town of Ferdinand in Essex County.

During the past two years a summary has been given of the rainfall in Vermont for the months of the fire season. As it is of interest to compare the records of precipitation during the past years with that of 1915, the following table is given. This table is made up from the reports of the United States Weather Bureau, giving the average inches of rainfall in Vermont during each month of the fire season since the year 1908.

INCHES OF RAINFALL BY MONTHS SINCE 1908.

Year	April	May	June	July	Aug.	Sept.	Oct.	Nov.
1908	2.7	4.7	2.8	3.0	3.7	.9	1.9	1.2
1909	3.0	4.6	3.1	2.6	3.1	4.2	1.5	2.0
1910	2.4	3.8	2.9	2.4	3.7	4.5	2.0	2.5
1911	1.1	1.3	3.9	3.5	3.9	3.8	4.1	2.2
1912	2.7	6.4	1.8	2.7	3.9	5.3	4.1	3.3
1913	1.9	3.3	1.7	3.7	1.5	2.2	4.9	2.0
1914	5.0	.9	2.9	4.1	4.5	2.1	1.4	2.3
1915	1.8	1.7	2.4	7.6	4.7	2.3	2.5	2.2

From the foregoing table it is noticed that the precipitation during the months of April, May and June was much below normal. Owing to this fact and carelessness of parties with fire, over 88 percent of the total number of fires for the year occurred during these three months. Following is a table giving the number and percent of fires during each of the months of the fire season.

Month.	Number of fires.	Percent of No. of fires.	Acres burned.
March,	5	3	6.7
April,	64	47	1,261.8
May,	25	18	361.0
June,	32	23	2,657.7
July,	2	2	2.1
August,	0	0	0.
September,	4	3	2.6
October,	2	2	70.
November,	3	2	35.1
Total,	137	100	4,397.0

Although the area burned over in 1915 was slightly more than that of 1914, the situation is very encourgaing when we compare this burned area with that of other New England states. During the past seven years, that is, 1909 to 1915, inclusive, the total acreage burned over in Vermont amounted to approximately 16,000 acres. While in one year alone, 1908, prior to the establishing of the Forestry Department, approximately 15,900 acres were burned over in the state. In 1908 it cost the state $9,039.32 for extinguishing forest fires. The total cost to the state for the same purpose for the past seven years amounts to but $5,565.15, or an average cost of about $800 per year against $9,039.32 in 1908.

It is realized that the fall months of the year 1908 were very dry, but by looking at the precipitation table it will be noticed that we have had just as dry months since then. Each year the forest fire traps have increased in the state and will continue to do so until some means are adopted to dispose of the large areas of slash which are left after destructive lumbering. Every year one or two fires burn over an area greater than all the others put together. One of these fires, starting in slash, occurred in the unorganized town of Ferdinand in Essex County.

This fire started about noon of June 5th, by sparks from a locomotive on the Grand Trunk Railroad. Owing to the slash and high wind the fire swept over some 1,000 acres before a fire fighting force could be effectively organized. Fire fighters were called from Island Pond and driving crews were sent by the Connecticut Valley Company and American Realty Company. These two companies have large holdings in this region and were, therefore, interested in preventing the fire from sweeping over their lands. It was not until after three days that the fire was under control and before it was completely out had burned over about 1,650 acres. A large part of the land was recently lumbered and the heavy slash, combined with the extra dry weather, resulted in making this territory a serious fire trap. The greater part of the area burned was owned by the Eaton Estate, and Connecticut Valley Lumber Company. The cost of extinguishing the fire amounted to $2,449.21, and the damage done to the land and growing stock is considerably more than this sum. Thus through the negligence of the Grand Trunk Railroad and the destructive lumbering of a few parties, the State of Vermont was obliged to pay about $2,500 for which it receives nothing. Because of the fact that the fire occurred in an unorganized town, the total expense fell upon the State.

Another large fire occurred in the town of Sunderland on the land which the Rich Lumber Company of Manchester is lumbering. This Company is cutting clean and leaving a bad slash which will make a fire trap for several years. An example of what might happen to this territory occurred June 6th, when a discharged "lumber jack" left an open camp fire burning. The fire spread, catching fire to a new camp and from there the sparks fell in the surrounding slash and in a few minutes a terrific fire was raging. This fire burned for four days over an area of more than 400 acres. If rain had not come to help the fire fighters it is doubtful whether the fire could have been stopped before it had burned over the entire area which has been lumbered. There is a danger of a very serious fire in this locality if the present slashing of timber continues without any thought of the reproduction.

Thus it will be seen that the fire hazard today is greater than it was in 1908, owing to the large areas of cut-over land, covered with slash. This year four fires burned over about 2,400 acres, or approximately 55% of the total area. All these fires started in the slash left by bad lumbering. In order to prevent these large fires, some means must be adopted to dispose of the waste in lumbering.

As there are two things necessary to make a forest fire: inflammable material, and a spark, it may be well to consider where the sparks come from. The following table gives this data:

Cause	Number of Fires	Number of Acres	Cost of Fighting	Percent No. of Fires	Percent No. of Acres	Percent Cost of Fighting
Brush burning,	44	656.9	$ 570.15	32	15	14
Unknown,	33	829.4	515.80	23	14	12
Railroad,	30	2,054.2	2,835.24	23	51	67
Smokers,	11	214.7	118.23	8	6	2
Fishers and Hunters,	8	160.6	126.03	6	3	2
Misc.,	8	459.3	116.41	6	10	2
Berry-pickers,	2	12.0	16.00	1	1	1
Lightning,	1	.1	2.40	1	0	0
	137	4,397.2	$4,300.26	100	100	100

From the above table it appears that carelessness in brush burning caused 32 percent of the fires and Railroads and Unknown causes are responsible for 23 percent each. The railroad fires burned over 51 percent of the total acreage for the year and also cost 66 percent. of the total fighting expense of the season.

The following table gives the number of fires, acres burned over and cost of extinguishing by counties:

Counties.	No. of Fires.	Acres.	Cost.
Addison,	6	313	$ 104.88
Bennington,	11	580.5	139.87
Caledonia,	5	128	89.73
Chittenden,	14	403	203.90
Essex,	14	1,818.9	2,565.35
Franklin,	3	35.8	25.98
Grand Isle,	0		
Lamoille,	5	53.1	164.46
Orange,	6	68	44.15
Orleans,	3	61	23.10
Rutland,	18	331.9	249.76
Windham,	32	238.5	377.72
Windsor,	12	279.5	157.90
Washington,	8	86	153.46
	137	$4,397.2	$4,300.26

The size of the fires during the year varied from one tenth of an acre to 1,650 acres. Eighty-two percent of them burned over 25 acres or less. The following tabulation gives this information:

Size of Fires	No. of Fires	Acres Burned	Cost of Fighting	Per cent. of No. of Fires
One acre or less,	27	13.7	$ 139.74	20
1 to 10 acres incl.,	57	245.5	448.19	41
10 to 25 acres incl.,	28	565	585.63	21
25 to 100 acres incl.,	21	1,173	549.91	15
100 to 500 acres incl.,	3	750	127.58	2
500 or more acres,	1	1,650	2,449.21	1
	137	$4,397.2	$4,300.26	100

Throughout the fire season patrolmen and lookout men were maintained in localities where the fire hazard was particularly great. Lookoutmen were stationed on Gore and West Pond Mountains in Essex County, Burke Mountain in Caledonia County, Camel's Hump, Pico and Stratton Mountains. Patrolmen protected the Long Trail of the Green Mountains between Killington and Mount Horrid. Also a patrolman was on the Grand Trunk Railroad between Summit and Lake. This man was paid through the co-operation of the Grand Trunk Railroad, Fitzgerald Land and Lumber Company, and the State. Besides the men who were paid by the U. S. Government, through the Weeks Law funds, there were several patrolmen and lookoutmen employed by the Vermont Timberland Owners Association. This organization, which is similar to one in New Hampshire, was founded early in the year, of land owners who control some 200,000 acres of Vermont timberlands. Those in the association pay a fixed tax per acre according to their acreage and the funds are used in employing patrolmen and lookoutmen and other protective measures. The Association constructed a tower and station on West Pond Mountain in 1915.

Other parties who co-operated with the State were Mr. Mortimer Proctor and the Chaffee Lumber Company, of Rutland. Mr. Proctor had a tower constructed on Pico Mountain, and also ran a telephone line to the summit. This mountain commands an extensive view to the north and will be of great value as a lookout for the patrolman on this section of the Long Trail. Mr. Chaffee, who owns considerable timberland in this section, made possible the reconstruction of the tower on Mount Carmel. This mountain with telephone line to the summit will make a valuable lookout station. No telephone, however, has as yet been constructed.

Much of the fire prevention work in Vermont, during the past few years, has been made possible through the co-operation of the U. S. Government under the Weeks Law. During the year 1915 the State received $2,490.73 from the Federal Government, all of which was expended in the employment of lookoutmen and patrolmen. These men are of great value, not only in discovering fires, but in cautioning people in the woods in regard to leaving camp fires burning,etc. Mr. Chamberlin, the lookoutman on Camel's Hump, during the past year warned over 500 people, and Mr. Burrington on Burke Mountain about 400.

During the spring, meetings for the instruction of forest fire wardens were held at Rutland on May 18th., Bellows Falls on May 19th., and at Lyndonville on May 20th. The attendance at these meetings was very good. The idea in holding them is to instruct the wardens in regard to the Forest Fire Laws of the State, the various ways of fighting forest fires, and also that the wardens may become better acquainted with those of the adjoining towns. At the Rutland meeting, Mr. Mortimer Proctor gave a very interesting talk on Vermont.

The wardens at the Bellows Falls meeting were the guests of the Board of Trade, which provided a dinner at the conclusion of the conference.

The Lyndonville meeting consisted of a field conference in the morning, and in the afternoon the wardens met for instruction in regard to the Forest Fire Laws, and to discuss the best methods of controlling forest fires. The morning session was held on the State Plantation at Lyndon, and much interest was shown by those present in the control of the drifting sand. After this session the wardens went to Lyndonville where Mr. Charles Darling, warden for Lyndon, entertained them at dinner. At the afternoon meeting Prof. John A. Foster, of Durham, N. H., gave a very interesting talk on the work which the U. S. Forest Service is doing in forest fire prevention. Others who spoke informally were, Mr. Elmer Darling, who erected the forest fire lookout station on Burke Mountain, and Mr. George R. Monell, Secretary of the Vermont Timberland Owners Association. The following day all those who desired had an opportunity to visit the Lookout Station on Burke Mountain.

The success of this meeting was due largely to the enthusiasm and generosity of Mr. Charles Darling, warden for the town of Lyndon.

Following is the summary for the fires of 1915:

SUMMARY OF FIRES FOR 1915.

Town	Date	Duration	Cause	Area burned acres	Damage	Expense	Warden
Arlington	April 25	3 hrs.	Smoker	15.	50.00	29.38	F. H. Farnham
Barnet	June 6	6 hrs.	Unknown	20.	100.00	7.00	Wilbur Nelson
Bloomfield	April 16	2 hrs.	Railroad	6.			G. R. Monell
"	April 17	4 hrs.	Railroad	4.	10.00		G. R. Monell
Braintree	April 14	4 hrs.	Brush burning	2.		1.75	Wm. Ladue
"	June 6	3 hrs.	Brush burning	3.		5.00	W. H. Perham
Brandon	April 25	3 hrs.	Along highway	15.	200.00	42.64	L. C. Bump
Brattleboro	Mar. 29	1 hrs.	C. V. R. R.	2.	20.00	3.25	F. R. Thomas
"	Mar. 29		C. V. R. R.	.1	4.00		F. R. Thomas
"	April 19	1 dy.	C. V. R. R.	4.	50.00	12.60	F. R. Thomas
"	June 1	2 dys.	Brush burning	2.	50.00	9.33	J. G. Stafford
"	June 3	3 dys.	Brush Burning	25	500.00	50.00	J. G. Stafford
Brighton	April 19	12 hrs.	Children	30		21.25	W. H. Hobbs
"	May 31		Fishermen	.1		14.50	W. H. Hobbs
Bristol	April 16	12 hrs.	Brush burning	.1		13.00	J. L. Guinan
Brunswick	April 18	6 hrs.	Smoker	25	500.00	8.00	James Conn
"	May 18		G. T. R. R.	3		1.00	James Conn
"	May 18	4 hrs.	Unknown	3		3.00	John L. Mills
"	June 27	6 hrs.	Brush burning	.7	1.00		J. P. Locke
Calais	May 29	2 dys.	Smokers	2	10.00	7.75	E. L. Wheeler
Cambridge	May 31	4 dys.	Unknown	10	100.00	88.90	E. M. Kneeland
"	June 6	60 hrs.	Unknown	6			E. M. Kneeland
Castleton	May 25	4 hrs.	Brush burning	4	20.00	9.00	A. A. Ransom
"	June 8	4 hrs.	Brush burning	2.5	5.00	5.00	A. A. Ransom
Chelsea	May 6	2 hrs.	Brush burning	7			R. A. Lyon
Clarendon	April 28	6 hrs.	Unknown	75	100.00	44.34	C. C. Colvin
Concord	April 18	3 dys.	Fishermen	15	75.00	28.48	E. A. Morse
"	April 22		Smokers	50	100.00	15.66	E. A. Morse

SUMMARY OF FIRES FOR 1915—(Continued.)

Town	Date	Duration	Cause	Area burned acres	Damage	Expense	Warden
Dummerston	April 20	15 hrs.	Brush burning	3	50.00		E. H. Brown
"	April 27	2 dys.	Railroad	25	500.00	60.00	E. H. Brown
Duxbury	Sept. 30	2 hrs.	Brush burning	.1		1.88	A. J. Durkee
"	Sept. 30	2 hrs.	Camp fire	.2			A. J. Durkee
Enosburg	April 17	7 hrs.	Unknown	35		8.00	C. H. Carpenter
Essex	April 19	8 hrs.	Unknown	88		12.40	David Demag
"	April 22	2 hrs.	C. V. R. R.	1		2.00	David Demag
"	April 22	14 hrs.	C. V. R. R.	25		11.00	David Demag
"	June 4	6 hrs.	Unknown	10		3.60	David Demag
"	June 9	5 hrs.	Unknown	6		13.75	David Demag
Fairfax	May 14	2 hrs.	Brush burning	.5	5.00	8.00	C. Southard
Fair Haven	May 9	10 hrs.	Brush burning	20	600.00	12.30	E. J. Bigelow
"	June 5	8 hrs.		50	4.00	12.23	E. J. Bigelow
Ferdinand	May 6	10 hrs.	Brush burning	10		3.00	L. W. House
"	June 5	3 dys.	G. T. R. R.	1650		2,449.21	W. H. Hobbs
Fletcher	Sept. 4	48 hrs.	Unknown	.3	200.00	9.98	C. F. Corse
Glover	April 19	13 hrs.	Brush burning	6	50.00	16.10	N. H. Drew
Grafton	June 6	12 hrs.	Unknown	1		3.00	V. A. Wilbur
Granville	April 22	4 hrs.	Unknown	10		6.00	E. W. Ford
Halifax	May 12	5 hrs.	Brush burning	6	20.00	3.25	H. A. Learnard
Hartland	April		Brush burning	1.5	35.00		D. C. Webster
"	April 17	5 hrs.	Brush burning	4			D. C. Webster
"	April 18	6 hrs.	B. & M. R. R.	25	150.00		D. C. Webster
Hubbardton	April 22	2 hrs.	Smoker	4		8.00	N. W. Chandler
"	June 13	3 dys.	Brush burning	20	50.00	9.60	N. W. Chandler
Huntington	May 1	24 hrs.	Brush burning	20		3.75	H. C. Russell
"	May 5	12 hrs.	Brush burning	20		13.79	H. C. Russell
"	June 3	72 hrs.	Brush burning	150		55.88	H. C. Russell

Huntington	June 5	48 hrs.	Brush burning	50		31.45	H. C. Russell
Ira	June 5	18 hrs.	Unknown	25			D. E. Lincoln
Jamaica	April 16	2 hrs.	C. V. R. R.	3		.88	L. E. Grout
Landgrove	Oct. 25	24 hrs.	C. V. R. R.	50		19.00	E. G. Fisher
Leicester	April 18	7 hrs.	C. V. R. R.	90	200.00	52.50	G. E. White
Mendon	April 18	1 dy.	C. V. R. R.	35		27.38	S. J. Bush
Middlebury	April 6	8 hrs.	Unknown	200	400.00	25.18	W. S. Trisdale
"	April 13	1 hrs.	Brush burning	3		2.20	L. S. Hunt
Middletown	June 5		Smokers	50		12.95	W. G. Harrington
Morristown	June 22	2 dys	Brush burning	12		56.16	Silas Chase
Mount Tabor	June 4	8 hrs.	Smokers	1		8.73	W. H. Allen
"	Oct. 25	12 hrs.	Hunters	20		24.60	W. H. Allen
Newbury	May 20	24 hrs.	B. & M. R. R	50	1250.00	23.40	G. E. Chamberlin
Newfane	April 20	6 hrs.	C. V. R. R.	25	75.00	15.58	J. F. Whitaker
Newport	June 5	3 dys.	Unknown	20	25.00	6.00	W. P. Wright
Northfield	June 6	40 hrs.	Unknown	3	55.00	19.65	G. W. Dillingham
Norton	June 2	8 hrs.	Fishermen	2		2.00	R. Robichand
"	June 6	12 hrs.	Fishermen	20		19.25	R. Robichand
Pawlet	June 7	3 dys.	Smoker	2		13.78	W. W. Folger
Plainfield	May 30	2 dys.	Fishermen	.5			J. A. Foss
Plymouth	May 1	4 hrs.	Fishermen	100	100.00	10.00	H. L. Moore
"	May 17	10 dys.	Brush burning	40	300.00	20.00	H. L. Moore
Poultney	April 25	1 dy.	Unknown	1		6.88	W. H. Parker
"	May 12	6 hrs.	Unknown	.4	15.00	8.01	W. H. Parker
Putney	April 24	10 hrs.	Unknown	5	25.00	14.75	M. E. Robbins
Readsboro	May 14	3 dys.	Unknown	6	10.00	1.00	V. S. Thayer
Richmond	April 20	48 hrs.	Brush burning	15	100.00	35.00	A. C. Berry
Ripton	April 30	5 hrs.	Berry pickers	10		6.00	J. E. Hodges
Rochester	April 20	8 hrs.	Brush burning	15		10.00	F. H. Perry
Rockingham	April 20	8 hrs.	Brush burning	5		7.96	C. K. Hughes
"	April 21	2 hrs.	Rutland R. R.	.5	1.00	4.52	G. A. Halladay
"	April 22	1 hrs.	Smokers	.2	1.00	3.64	G. A. Halladay
"	April 27	2 hrs.	Brush burning	2	25.00	6.52	G. A. Halladay
"	May 15	4 hrs.	Brush burning	18	30.00	16.50	H. A. Stoddard

SUMMARY OF FIRES FOR 1915—(Concluded.)

Town	Date	Duration	Cause	Area burned acres	Damage	Expense	Warden
Rockingham	June 5	3 dys.	Hunters	3	10.00	27.20	G. A. Halladay
"	Nov. 13	4 hrs.	Picnic Party	.1	1.00	2.00	H. A. Stoddard
Roxbury	April 22	1½ dys.	Unknown	30	50.00	37.13	M. M. Goodell
Rutland	April 26	3 hrs.	Railroad	4		1.82	J. H. Callahan
"	May 9	6 hrs.	Unknown	3		2.50	J. H. Callahan
Sandgate	April 15	4 dys.	Unknown	20	10.00	3.00	W. C. Peck
"	June 25	4 hrs.	Brush burning	10	10.00	3.50	W. C. Peck
Shaftsbury	June 2	½ hrs.	Unknown	.5		2.00	E. J. Lyons
Sheffield	June 4	5 dys.	Unknown	75	300.00	65.23	F. E. Bickford
S. Burlington	April 16	5 hrs.	Brush burning	5		11.58	E. W. Butler
"	April 19		Brush burning	3			E. W. Butler
Springfield	May 30	15 hrs.	Brush burning	15.0	100.00	15.00	W. D. Stearns
St. Johnsbury	April 12	1 dy.	Brush burning	25	100.00	17.50	Chas. Weeks
Stamford	April 15	12 hrs.	Unknown	75	150.00	15.00	W. H. Seeger
Stockbridge	April 18	1 hr.	Ct. fr. burn. bl.	3	10.00	4.00	L. F. Newell
"	April 27	6 hrs.	White R. R. R.	20.0	50.00	33.10	L. F. Newell
Stowe	July 22	4 hrs.	Lightning	.1		2.40	W. H. Russell
Sunderland	April 21	4 hrs.	Unknown	2.0		8.87	H. B. Lawrence
"	April 20	2 hrs.	Brush burning	1.5	25.00	10.00	H. B. Lawrence
"	April 24	1 hrs.	Smokers	.5		1.60	H. B. Lawrence
"	June 6	4 dys.	Leaving fire	400.0	700.00	46.52	H. B. Lawrence
Thetford	April 15	3 hrs.	Brush burning	4.		2.00	A. B. Palmer
Townshend	Mar. 24	1½ hrs.	C. V. R. R.	1.5		4.50	C. H. Willard
"	Mar. 29	½ hr.	C. V. R. R.	3		23.00	C. H. Willard
"	Mar. 31	½ hr.	C. V. R. R.	.1		3.00	C. H. Willard
"	April 14	½ hr.	C. V. R. R.	1		14.00	C. H. Willard
"	April 15	3 hr.	C. V. R. R.	2.0	25.00	22.00	C. H. Willard
"	April 16		C. V. R. R.	.5	25.00	4.00	C. H. Willard

Townshend	April 17	1 hr.	C. V. R. R.	1		3.00	W. H. Taft
"	May 5	1 hr.	C. V. R. R.	1	10.00	1.00	W. H. Taft
"	May 10	9 hrs.	C. V. R. R.	20	100.00	41.00	C. H. Willard
"	May 11	2 hrs.	C. V. R. R.	1.5	10.00	2.50	C. H. Willard
Vershire	June 7	1 dy.	Unknown	2		12.00	C. W. Grant
Waterbury	April.20	24 hrs.	Brush burning	50	50.00	82.45	D. J. Adams
Waterville	Nov. 11	9 hrs.	Brush burning	25	300.00	17.00	G. M. Morrison
Weathersfield	April 22	5 hrs.	Unknown	50	200.00	29.80	A. L. Divoll
Westford	Sept. 21	12 hrs.	Unknown	2		6.00	H. E. Huntley
Westminster	April 25	3 hrs.	Smoker	65		8.74	D. P. Wright
"	July 18	3 hrs.	Berry pickers	2		10.00	D. P. Wright
"	Nov. 9	4 hrs.	H. tension 1.	10			D. P. Wright
Westmore	June 5	8 hrs.	Brush burning	35	200.00	1.00	E. J. Wheeler
West Windsor	June 13	1 day	Camp fire	1		18.00	J. E. Donoghue
Wheelock	April 26	2 hrs.	Brush burning	3			T. Buckley
"	April 29	1 hr.	Brush burning	5			T. Buckley
Williston	April 19	3 days	Brush burning	8		3.70	A. Brown
Windsor	April 25	4 hrs.	Unknown	5		18.00	E. Anderson
Worcester				.2	10.00	4.60	C. Howison
				4,397.2		$4, 00.26	

CLOSE UTILIZATION OF THE FOREST.

By B. A. Chandler, Assistant.

Practically since the Forestry Department was created it has been giving advice to private owners, if such owners were willing to pay the expenses of a forester while doing the work. In the fall of 1913 the demand for this kind of work became so great that special rules were made, which are repeated below:

1. The Department will send one or more men to inspect any land in the State, and advise on its management. The only cost will be that of travelling expenses to and from Burlington, and board while doing the work.

2. The Department will supervise the marking of trees which should be cut. On tracts of less than ten acres the owner will be expected to furnish one man; on larger tracts two men.

3. Working plans for private forest tracts will be made under special agreements, the expense being divided and the party giving satisfactory guarantee that the plan will be executed.

The Forestry Department does not estimate timber for private owners.

A report on the work, done under the recommendations of the previous inspection, will be required before another inspection will be made.

The Department reserves the right to publish the reports on such inspections, and the results of work done under such recommendations.

In other words, the Department stands ready to do anything within the limits of the funds available which will actually result in the practice of forestry on private land, but does not feel justified in doing things for private owners which may mean greater profits for the individual without any prospect of greater and better forest resources for the State.

This work for the private owner is developing in some cases into a fixed policy carried out under the direction of the Department. Two cases will illustrate.

The north branch of the Winooski River rises in Worcester and flows southerly joining the Winooski at Montpelier. A large percentage of the soil in this valley is strictly a forest type of soil, and unless the forest resources of the valley are maintained it will be unable to support the population in the future that it has in the past.

C. C. Putnam and Son own large areas of forest land in this region, and have for many years operated a mill. Some four or five years ago they sold the stumpage on their more inaccessible holdings and their mill. They realized the necessity of maintaining the forest resources of the valley, but at that time did not know of the offer of this Department, and therefore, simply imposed a diameter limit in their cutting contracts. This has worked out better than having no restriction on the cutting, but not as well as having the timber marked for cutting.

About 1913, C. C. Putnam and Son started another mill farther down the valley and began cutting on their more accessible holdings. About this same time they became interested in the work of this Department, and began planting. Since then they have had all the timber to be cut on their land, which was not tied up by previous contracts, marked by some representative of this Department. On such land the jobbers are allowed to cut only such trees as are marked.

In all mixed hardwood stands there are always a great many poor species, crooked or decayed trees, and small sized trees which should be removed in order to get reproduction of desirable species or faster growth of the remaining trees, but which cannot be cut because they have no market value. Due to an intimate knowledge of the markets, and a mill which was adapted to the economical handling of low grades of lumber and the manufacture of different products, it has always been possible to mark closer on these holdings than in most mixed hardwood stands. During the last year, however, Mr. Putnam has been instrumental in starting a new mill which manufactures handles, toys and all kinds of turned specialties, with the result that even closer utilization is possible. Material which will not even make novelty stock is used for wood so far as the local wood market permits.

Thus their holdings are being put in good productive condition. Stands of mixed hardwood where there is a fair mixture of ash and basswood, are cut so as to encourage the growth of the immature trees of these species, as well as to bring about the soil moisture, and light conditions, which will encourage their reproduction. In other places yellow birch and hard maple are encouraged, while in still others spruce growth and reproduction are sought. Where the species represented in the stand are all poor and where the individual trees are all over mature so that it is impossible to get desirable natural reproduction, some small areas are cut clean and planted the following spring.

In the little valley made by the stream which joins the Winooski at North Duxbury, there is another situation which, although similar in some ways, has been worked out very differently. Even a larger percentage of the soil in this valley is of a forest type and practically all the inhabitants of the valley work three-fourths of the year in the woods or mills. Some twelve years ago a big fire ran across the head of this valley killing the timber on a large area and greatly diminishing the water power on the stream below. As the result of this fire and very careless lumbering in the past, the forest resources are getting low. The State owns, by gift of the late Col. Joseph Battell, a great deal of the burned land at the head of the valley, and is planting large areas every spring.

Furthermore, some of the stands which were culled of their then merchantable timber, when the valley was first opened up, will be ready for another cut in a few years. Probably there is enough old growth hardwood, spruce and hemlock left in the valley so that if it is cut conservatively and manufactured closely the valley can support its present population until these two classes of young growth can be cut.

The mill men of the valley realize this situation. In rebuilding after a fire a year or two ago, Mr. Elliott, one of these mill owners, put in machinery which would make possible closer utilization of logs. He furthermore pursuaded a non-resident, trustee of a tract on which he was buying logs, to have the trees marked by this Department, and to sell him only the marked trees. He made this suggestion when he might have bought all the timber, and let the jobbers cut it as they pleased, simply because he saw the necessity of keeping up the forest resources of the valley as a future supply for his mill. The Department maintains a man on its reservation at the head of this valley from early spring to late fall, taking charge of the plantings and watching for fire on the trails and from the top of Camel's Hump. As a result of the suggestion, Mr. Elliott made to the trustee, this forest ranger was transferred to the pay-roll of said trustee in the fall and marked the trees which should be cut, inspected the jobbers, not only as to the cutting of marked trees, but in all ways that jobbers need inspection, and also did the scaling for the trustee. It will probably take three or four years to cut over the tract in question.

In both these valleys the forest resources, and thus their ability to support a population, are being maintained, in so far as there particular areas are concerned. The percentage of land thus brought under management is greater in the latter case. The results are about the same in both valleys, but when the tract is large enough to warrant it, the arrangement in the latter valley is much better because the man who does the marking is also doing the inspecting and scaling, and can, therefore, enforce the marking as well as adjust any difficulties which arise. The jobbers are usually ready to abide by the marking when the reasons for leaving certain trees are explained to them. When, however, they only meet the man who does the marking once or twice for the winter, and so do not have any personal acquaintance with him, they are apt to object to leaving trees which, from their point of view, ought to be cut. If, however, some jobber is not open minded enough to be fair and the contracts are properly written, and the man who does the marking is also scaling, he can enforce his marking to better advantage.

It is hoped and expected that in both valleys the system will extend to other tracts. The Department has other men available during the winter months who are capable of marking and inspecting lumber jobs and scaling.

EXPENDITURE OF STATE APPROPRIATION FOR THE YEAR ENDING JULY 1, 1916, UNDER No. 17 OF THE ACTS OF 1915.

Salaries, State Forester and Assistants	$ 3,810.04
Charles Downer State Forest	2,774.08
State Nursery at Burlington	1,234.07
West Rutland State Forest	996.33
Railroad, livery, hotels, etc., Forester and Assistants	902.04
Clerical force	735.00
Camel's Hump State Forest	561.96
Fire Prevention	435.29
Putnam State Forest	364.50
Instruments, tools and office supplies	261.15
Postage, stationery, telephone and telegraph	199.44
Mansfield State Forest	192.57
Exhibits, Insurance and miscellaneous expenses	158.88
Proctor-Piper Forest	146.11
Pine disease eradication	90.29
Lyndon State Forest	71.86
Freight and Express	66.39
	$13,000.00

RANGER'S CABIN ON THE LEE RIVER, MANSFIELD STATE FOREST.
FORESTRY STUDENTS IN CAMP.

REPORT OF RECEIPTS AND EXPENDITURES OF MONEY RETURNED TO THE STATE TREASURER UNDER No. 17 OF THE ACTS OF 1915.

RECEIPTS.

For trees sold from State Nursery	$ 1,941.90
For trees and farm produce sold from Downer Forest	478.82
For wood sold from Camel's Hump Forest	117.27
For wood sold from Geo. Aitken Forest	78.69
For refund on travelling expenses	47.53
For wood sold from L. R. Jones Forest	35.00
For gravel sold and rent of pasture—West River Forest	18.00
For building sold from West Rutland Forest	15.00
For hay sold from Mansfield Forest	5.00
	$ 2,737.21

EXPENDITURES.

State Nursery	$ 1,941.90
Downer State Forest	502.23
Camel's Hump State Forest	117.27
Miscellaneous	70.28
Travelling expenses	47.53
Geo. Aitken State Forest	26.00
West Rutland State Forest	15.00
L. R. Jones State Forest	6.00
West River State Forest	6.00
Mansfield State Forest	5.00
	$ 2,737.21

Pamphlets.
Vermont.
V5P3
v.3

~~C. Sh~~ ~~6/26/52~~
~~T.B. Yerke~~ ~~5/18/61~~
~~Renewed 1-20-61~~
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